ASTRONOMY®

GALILEO LOOKS AT THE MOON

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Great White Spot Erupts on Saturn

Big Scope Reviews: Obsession 20-inch and the NGT

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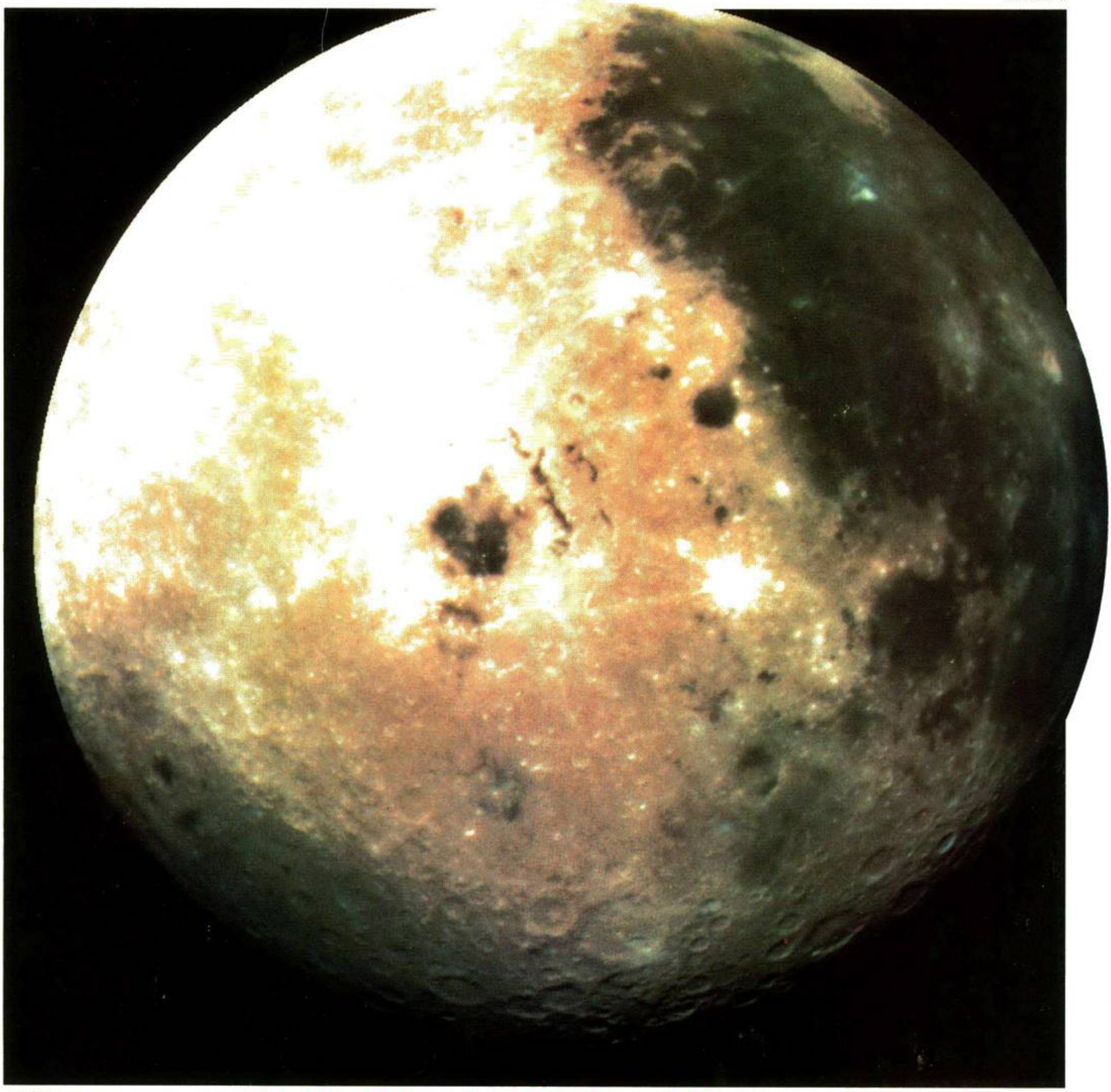

Galileo Flies Past Earth and Moon — Returns Photos

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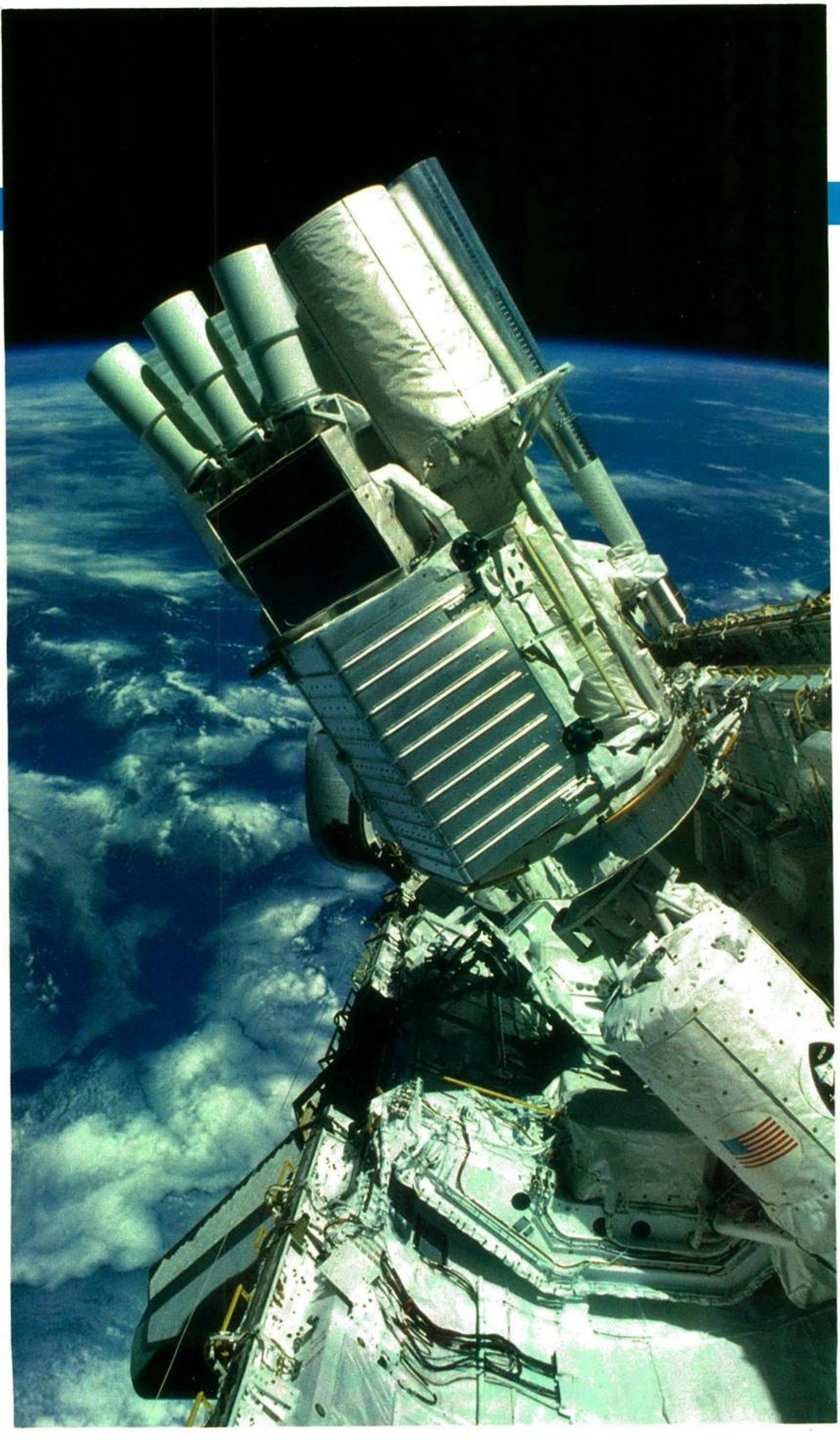
ON THE COVER: In early December the Jupiter-bound spaceprobe *Galileo* raced past Earth and the Moon. As it departed the Earth-Moon system, *Galileo* took this image of a side of the Moon we can never see from Earth. The prominent bull's-eye feature is Mare Orientale. NASA/JPL photo.



FROM THE VANTAGE POINT OF SPACE the *Astro-1* array of telescopes revealed the ultraviolet and x-ray universe as astronomers had never seen it before. A preliminary report on last December's shuttle mission appears on page 24. NASA photo.

ASTRONOMY

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The Audit Bureau

Behind the Scenes

SERENDIPITOUS DISCOVERIES

Major advances in astronomy sometimes arrive unbidden. An opportunity arises, and someone exploits it. ASTRONOMY's feature stories this month share this: each is about astronomy that happened — more or less — by accident.

As a young man, Clyde Tombaugh was hired to search for the supposed ninth planet in the solar system, the mysterious "Planet X." His job was to shoot photographs a few days apart and compare them. Clyde found Pluto after just nine months, but he continued searching because Pluto was too faint to be the "real" Planet X. In the course of examining most of the northern sky, young Clyde observed the distribution of tens of thousands of galaxies through the eyepiece of a blink comparator. And he realized that galaxies cluster.

It is unfortunate that Clyde's discovery went unrecognized. The young man lacked sufficient "clout" to pursue a discovery. It is doubly unfortunate because the clustering of galaxies is without doubt a more important discovery than the discovery of Pluto was. David Levy's story of Clyde Tombaugh's discovery begins on page 44.

Galileo's mission to planet Earth is equally serendipitous. An Earth flyby was certainly not part of mission planning until NASA abandoned the Centaur upper-stage booster after the *Challenger* explosion. Mission plans changed: in order to gain orbital energy to reach Jupiter, *Galileo* had to perform two Earth flybys.

Seeing the flybys as an opportunity to check out *Galileo*'s science instruments, the science team wondered what could be done with Earth as a target of opportunity. They then recognized a chance to gather significant new data about our planet. Robert Burnham's report begins on page 30.

Yet another accident of fate led to a boon for radio astronomy. From an abandoned satellite dish in South Africa came a survey of the southern radio sky. You can see the resulting maps of the radio sky in Gerrit Verschuur's article between pages 39 and 43.

Professional astronomers were not searching for a Great White Spot on Saturn. Instead, they were paying close attention to Jupiter, monitoring the return of the South Equatorial Belt. Thus it fell to an amateur astronomer in Los Angeles to discover Saturn's huge eruption of cloud. You can argue that the discovery was not serendipitous because Alberto Montalvo monitored Saturn on a regular basis. In any case, Alan Dyer's report begins on page 36.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

ASTRONOMY

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Letters

The Light Pollution Show

Phillip J. Loss' suggestion to use planetria to dramatize the effects of light pollution is an excellent idea (Letters, November 1990). An old experience comes to mind.

At one time, the Adler Planetarium in Chicago began each sky show by displaying the appearance of the sky as visible from Chicago that night. This enabled you to see stars down to 4th magnitude or so. The announcer then told the audience that we were traveling to a dark-sky site, the way nature intended the sky to appear. The planetarium blackened, and all of the faint stars, the Milky Way, and assorted fuzzy glows sprang into view. The audience gasped with amazement during every single show.

The world's planetaria can be powerful places to excite the public about the stars and help prevent the spread of light pollution. Let's use them! — *Joseph Anderer, Mountain Home, Arkansas*

— The Charles Hayden Planetarium at Boston's Museum of Science used to do the same thing. Have most planetariums stopped doing this in their sky shows? Should we amateur astronomers urge them to use this trick for a little benign propaganda on behalf of darker skies?

A Little Volcano Spotting, Anyone?

I greatly enjoyed the article "How to Find a Lunar Volcano" by Michael T. Kitt (December 1990 issue). While many astronomers believe lunar domes represent shield volcanoes, others such as the now deceased observer Alika Herring suggest they represent surface upheaval by underlying forces such as magma. Some domes, such as the one west of Kies, have surface pits consistent with a shield volcano, but others do not. The crater pit in Herring's model would be formed by collapse or explosion.

After reading the article and finding a few of these domes, observers might wish to take part in the Association of Lunar and Planetary Observers' lunar dome survey. I am currently in charge of this program and would be happy to send interested readers information on our activities. — *Jim Phillips, Lunar Dome Recorder, ALPO, 101 Bull Street, Charleston, South Carolina 29401*

Thank you for the great article on lunar domes. I found all of them with my 6-inch schiefspiegler telescope and

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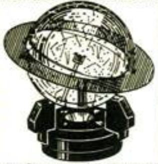

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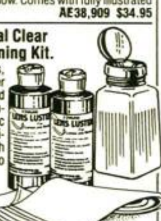

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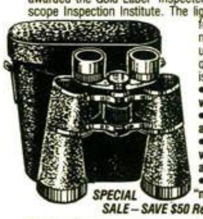

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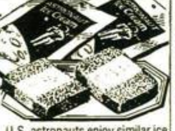

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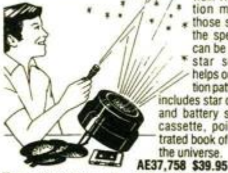

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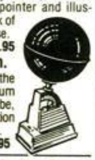

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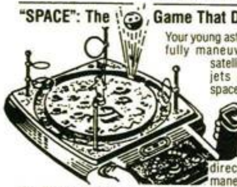

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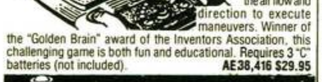

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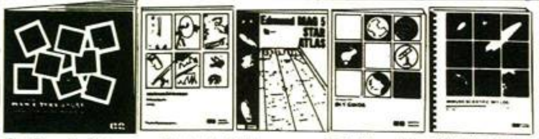

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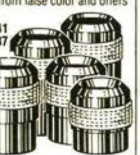

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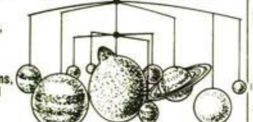

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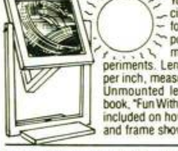

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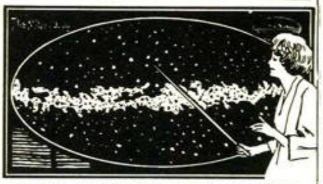

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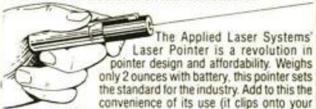

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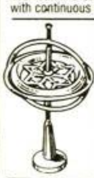

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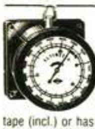

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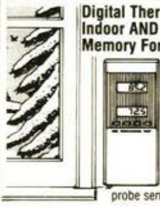

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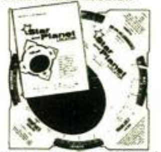

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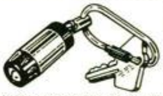

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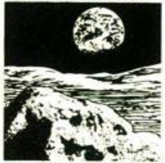

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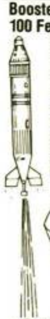

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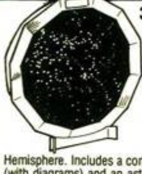

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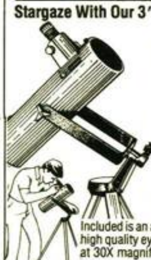

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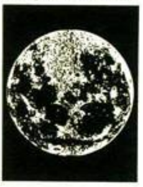

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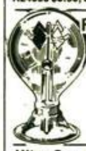

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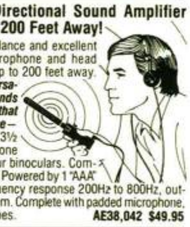

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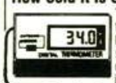

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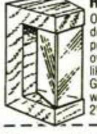

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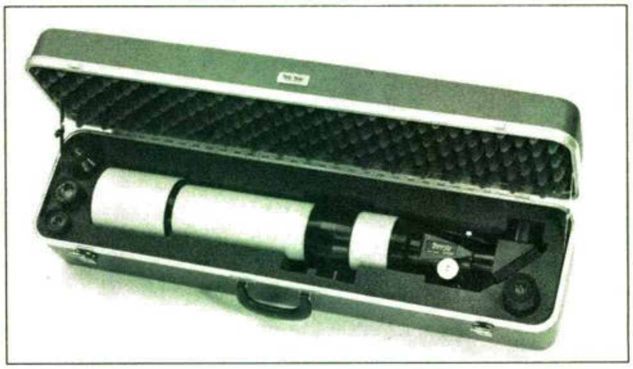

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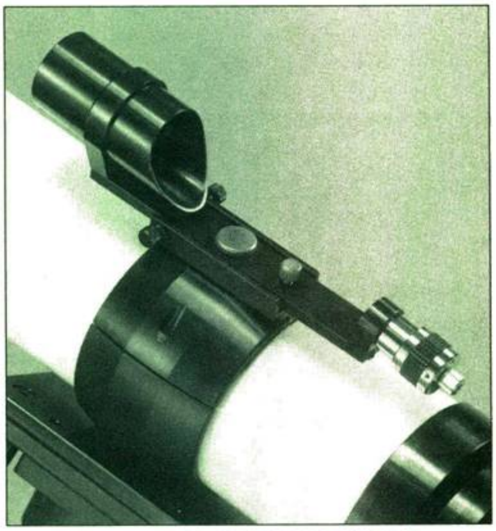

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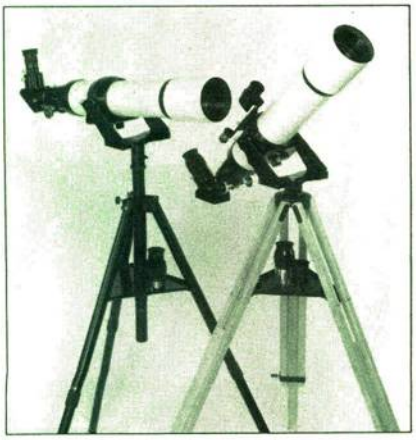

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greatly enjoyed the experience. With more and more of us living in places where deep-sky objects cannot be easily observed, I found comfort in the article's demonstration that there are lots of other interesting things out there to see. — Patrick Bailey, Lancaster, Georgia

The Cops are Coming

Ken Clark's experience with the police (Letters, November 1990) prompted me to recall my own experiences. While observing I've also been subjected to police spotlights in the dark and have been thrown out of a public site. Indeed, I've virtually never been concerned about criminals — the bad guys are generally a cowardly lot who shun total darkness. Rather, I've been scared genuinely by armed agents of the state who have felt it necessary to vigorously investigate "perpetrators" who stand around loitering in the dark, looking through these funny tubes. Seriously, most of the time I don't mind it, and have even shown a number of policemen some interesting sights in the sky. But with the proliferation of crime in this country, you would think officers of the law might have something more useful to do! — *William Hathaway, Severn, Maryland*

Vancouver, the Musical Center

I would like to point out an error in your story about the 1990 General Assembly of the Royal Astronomical Society of Canada (October 1990). The article mentioned some singing at the meeting and credited the song to the Winnipeg Centre of the RASC. While I certainly don't want to put down the talents of the Winnipeg Centre, the song originated with the Vancouver Centre, of which I am the president. I wrote the song myself. When this error was pointed out to me, there were howls of outrage (mixed with laughter) from the Vancouver Centre members. (The Vancouver and Winnipeg centres have maintained a friendly competition on such things for years.) Please keep your centres straight! — *Gerry Knight, Vancouver, British Columbia*

Remembering Tycho

I enjoyed William J. McPeak's great article on Tycho Brahe (December 1990). No greater accolade can be made for Tycho as an astronomical observer than the following quotation by Johannes Kepler from his book *Astronomia Nova*. When Kepler found that his computations for the positions of Mars were off by a mere 8' — having used Tycho's observational data — he would not accept the error as Tycho's and wrote:

"It behoves, to whom by divine benevolence such a very careful observer as Tycho Brahe has been given, in whose observations an error of 8' of Ptolemy's computation could be disclosed, to recognize this boon of God with thankful mind and use it by exerting ourselves in working out the true form of celestial motions."

Mr. McPeak wrote that "Tycho is a forgotten man." He may seem forgotten today, but was certainly appreciated in his time. — *William Homann, San Marcos, California*

Where are We Going?

I had to respond to your Viewpoints article "Where is Astronomy Going?" (September 1990). The impression I get is that beginners are often confused by the complex battery of equipment that some amateur astronomers bring to star parties. As a member of a small astronomical group in a small town, I have had a different experience. If I show a group of newcomers a bright object like Saturn or Jupiter, their first reaction is incredible excitement: "Is that star up there really Saturn?"

A particularly good technique is to get newcomers involved with what they are seeing. After the initial burst of excitement over Saturn, I usually ask viewers if they can see a faint star near the planet. When they say yes, I have fun informing them the faint star is actually Saturn's moon Titan. They're overjoyed!

Introducing new people to the hobby is where astronomy should be going. By making people aware of real science and the universe around us, we'll gradually reduce the number of people who believe in pseudoscience or just don't know about their place in the cosmos. — *Karenz Burk, Creswick, Victoria, Australia*

— We agree heartily. One of the most productive roles that amateur astronomers can fulfill is to publicize and promote the growth of amateur astronomy.

Testing the NGC-MAX

I enjoyed the review article on the NGC-MAX (November 1990), but wanted to describe my experience for you. I bought my unit from Astronomics and received it in good order. As Mr. Dyer pointed out, installation was a snap, even on my homemade 12.5-inch reflector. Using the NGC-MAX is such a pleasure that I now wonder how I ever got along without it. However, I did experience some problems.

During my first two nights observing, I discovered that some well-known guide star magnitudes are incorrect. For example, Vega and Arcturus are given as "?" rather than "0.0." Second, the 24-hour advertised battery life is actually more like three or four hours. Third, the advertised memory store of "363 interesting stars" turned out to be 241 interesting stars. Fourth, the coordinates for Mars were incorrect. And fifth, the instructions were in some areas inadequate.

I enjoyed the article but feel the reviewer was overly positive about this product. But if you were to ask if I would buy one after discovering these problems, I would still answer yes. — *Dick Buma, Lakewood, California*

Geminid Watching

I greatly enjoyed watching this year's Geminid meteor shower that peaked on the night of December 13/14, 1990. I saw many bright meteors. Between 8 and 9 UT I counted 74 shower members and six sporadic meteors. The following hour I counted 106 Geminids and 8 sporadics, and between 10 and 11 UT I saw 81 shower members and 6 sporadics. Did other readers feel, as I did, that this year's Geminids came in "clumps?" — *Bill R. Smith, Ukiah, California*

Corrections

On page 78 pf the November 1990 issue, the photograph of M42 should have been credited to Mike Sisk.

In the February letters column on page 10, a line was inadvertently ommitted. The paragraph that begins at the bottom of page 6 should read: "Astronomers on a limited budget should consider a 2" diagonal and low-power eyepiece as an alternative to computer-aided finding devices. For some observers, the catalog aspect of the NGC-MAX and ability to eliminate polar alignment may be less valuable than wide-field views and an enhanced ability to see faint, extended objects." □

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length or clarity.

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Barlows		24.5mm	139
122 1-1/4" 2x ..	45	32mm	209
140 1-1/4" 2x ..	69	40mm	299

Mention this ad for *FREE* shipping!

New TeleVue's w/Eyeguard!

Plossl		**Naglers**	
Up to 26mm	$79	4.8mm	$149
32/40mm	99	7mm	179
55mm	209	9mm	219
Wide Field		12mm Type2 ..	249
15mm	129	16mm Type2 ..	279
19mm	139	20mm Type2 ..	349
24mm	159		
32mm	229	**Barlows, 1-1/4"**	
40mm	289	2.5x or 1.8x	79

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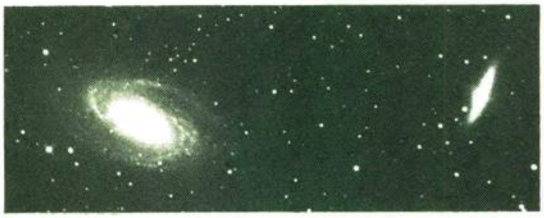
LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH



Galaxies M81 (left) and M82 (right) in Ursa Major. 30 minute exposure by Martin Germano using 103aF, and an 8" f/5 telescope with a LUMICON 2" Newtonian EASY-GUIDER. Visually M82 shows much mottling and detail. Spiral detail in M81 is hard to see visually.

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK!

Oracle 3" f/7.4 Triplet Apochromat	$750
Genesis 4" f/5 4 element fluorite	$1450
Renaissance 4" f/5.5 refractor	$1450
Complete Equatorial Mount	$795
Motor Drive for above mount	$198
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$89
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow	$219
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 85°	$145
24mm Wide-Field, "superb," 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "awesome," 65°	$299
4.8mm Nagler, 82° field	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, "the best"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$179
2" Paracorr Visual Coma Corrector	$298

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount .. $54
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$47.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. 1.3-1.8" mirrors have enhanced silver coatings (98-99%R). The extra 8-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50** 4.00" **$149.00**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror) **$99.50**
2" (1.83" mirror)(see photo above) .. **$159.00**

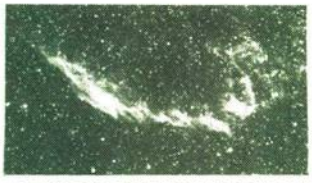
LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter or the LUMICON UHC Filter**



"I CAN SEE THE VEIL NEBULA!"
Rich Zepernick saw the Veil Nebula for the very first time with a LUMICON UHC Filter. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.75" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%), Premium	$159.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines .... **1¼" $99.50, 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$16.00
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$20.00

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

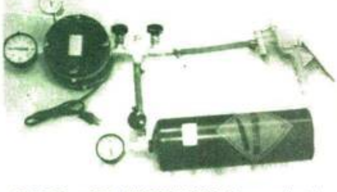
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$295**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$89.50**
Illuminated reticle eyepiece system .. **$99.50**
Guider for Hasselblad **$350,** Mamiya 645 **$199**
Adapter for Pentax 6x7 med. format ... **$89**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$185,** Mamiya 645 **$159**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$195,** Mamiya **$96**

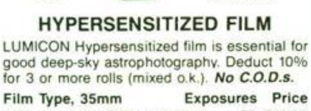
WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope) .. $99
NEW Deluxe Digital Qtz. Drive Correc. **$298**



NEW SRV3200

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	$10.95
SRV3200, fastest of all, color neg	24	$13.95
Konica SR-V3200, unhypered	24	$8.50
Konica SR400, fine grain color neg	12	$10.95
3M 1000, fastest slide film	12	$12.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$6.95

LUMICON means INNOVATION

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IMPROVED LUMICON® SKY VECTOR II™ $589

Now 1500 of "Best" Deep-Sky Objects in Computer Memory

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- Digital right ascension readout to 1 minute of right ascension (RA)
- Digital decl. readout to 10 arc-min
- 4000 pulse (0.09° accuracy) high resolution encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, date, sidereal time, etc.
- 9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision high resolution digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

LUMICON SKY VECTOR™ for Meade 2080, Meade 2120 *(Specify)*	**$399**
For Celestron C-8, C-11 *(Specify)*	**$399**
For Coulter Odyssey 8", 10", 13", 17½"	**$399**
For any alt-azimuth (Dobsonian) scope	**$399**
For Celestron C-14 (rewire dec. motor)	**$498**
SKY VECTOR KIT (for skilled ATM's)	**$369**

Reference catalogues (1000's of objects)

Burnham's *Celestial Handbook*, I, II, III	**$36.85**
Revised New General Catalogue (all NGC and IC, Epoch 1975.0)	**$35.00**
Sky Catalogue 2000.0, Vol. II	**$29.95**

Only the LUMICON SKY VECTOR II has size, true **visual** magnitude, and complete **visual** appearance description for **all** 1500 objects in memory.

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1735+273
RA
DEC
MODE
STAR
UP
DOWN
Sky Vector II™
COMPUTER SETTING CIRCLES
LUMICON ®

LUMICON SKY VECTOR II™ Computer with 1500 object memory, digital readout of coordinates, easy-to-use controls, object size, visual magnitude and visual appearance descriptions.

Please specify telescope type:

LUMICON SKY VECTOR II™ for Meade 2080, Meade 2120 (*Please specify*)	**$589**
For Celestron C-8, C-11 *(Specify)*	**$589**
For Celestron C-14 (rewire dec. motor)	**$665**
For Coulter Odyssey 8",10",13"17½"	**$589**
For any alt-azimuth (Dobsonian) scope	**$589**
SKY VECTOR II (upgrade, computer only)	**$395**

The **LUMICON SKY VECTOR II**™ has all the features of the regular SKY VECTOR, but has 1500 of the best deep-sky objects in memory, selected by noted observer Steve Gottlieb, along with their coordinates, size, true visual magnitude, and other descriptive data. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

LUMICON SKY VECTOR II FEATURES:

- Includes **size, true visual magnitude & complete visual appearance description** for all 1500 objects
- All 110 Messier objects
- Brightest 31 alignment stars
- User definable catalogue of 25 objects retained in memory
- 703 galaxies, groups & clusters
- 228 best open star clusters
- 170 best planetary nebulae
- 77 emission & reflection nebulae
- 10 best dark nebulae
- 107 best gobular star clusters
- 205 best colored & multiple stars
- Displays Uranometria 2000.0 chart no.
- ROM upgradable for planets, extended object lists, etc.
- TIMER function, elapsed time & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
- May align on any of the 1500 objects in memory

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although, designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces. Clear aperture = 1.8".

LUMICON Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$169.50**
2" EASY-GUIDER (Mamiya 645)	**$199.50**
2" Adapter for Pentax 6x7	**$85.00**
2" Adapter for Hasselblad	**$185.00**
2" Adapter for Bronica SQ-A	**$175.00**
2" Extension for viewing	**$26.00**

MEADE® TELESCOPES

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LUMICON ACCESSORIES

NEW PREMIER SERIES TELESCOPES

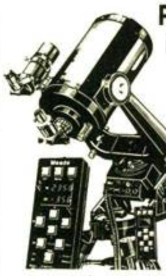
All Meade Premier Series telescopes **include Smart Drive (SD) permanent periodic error correction**, multi-coated enhanced optics (MCOG), Electronic Command Center (ECC), and **include** advanced LX6 all-electronic drive system. Select f/10 or f/6 optics, and select only the optional features you **need.** The 8" has a 6X30 finderscope and the 10" has an 8X50 finderscope. SD = Smart Drive.

2080 Model 40SD, 8" f/10	**$1650**
2080 Model 46SD, 8" f/6	**$1799**
2120 Model 40SD, 10" f/10	**$2099**
2120 Model 46SD, 10" f/6	**$2298**
Model 2600 16" f/10	**$9950**

Options Enhance Performance

Super Wedge for 10"	**Add $299**
ECC Electronic Command Center	**$275**
#39 Declination motor	**Add $109**
Digital setting circle	**Add $399**
2" Star diagonal	**Add $179**
LUMICON Cassegrain Easy-Guider *(Please specify camera)*	**Add $225**
LUMICON Giant Easy-Guider (for #40) *(Specify camera)*	**Add $395**
LUMICON Giant Easy-Guider (for #46) *(Specify camera)*	**Add $295**

PREMIER 2080
MODEL 50SD
$1950



Meade Premier 2080 Model 50SD

MEADE SERIES 4000 EYEPIECES

Super Plossl: 6.4mm, 9.7mm, 12.4mm **$89** 15mm, 20mm, 26mm **$89; 32mm $109**

Super Wide-angle: 13.8mm **$129,** 18mm **$135,** 24.5mm **$149,** 32mm (2") **$219**

Ultra Wide-angle: 4.7mm **$149,** 6.7mm **$179,** 8.8mm **$209,** 14mm **$249**

SCHMIDT-CASSEGRAIN

2045D 4" f/10 w/motor drive	**$695**
2080A Standard 8" f/10 w/tripod	**$999**
2080B Std. w/tripod, MCOG	**$1099**
2080 Model 50SD, 8" f/10	**$1950**
2120 Model 50SD, 10" f/10	**$2399**
2120 Model 50SDH, 10" f/10 w/Super Wedge, Smart Drive	**$2698**
2080 Model 56SD, 8" f/6.3	**$2099**
2120 Model 56SD, 10" f/6.3	**$2595**
2120 Model 56SDH, 10" f/6.3 w/Super Wedge, Smart Drive	**$2894**
Dew shield - essential! 8" **$119;** 10"	**$129**
LUMICON EASY-GUIDER for 2080	**$225**
EASY-GUIDER (f/4-f/10) for 2120	**$395**
CAT command control, 8200 objects	**$999**

SCHMIDT-NEWTONIAN

MTS-SN6, 6" f/5, #788 drive	**$649**
MTS-SN6 w/drive, MCOG	**$698**
MTS-SN8, 8" f/4 w/drive, MCOG	**$795**
#36 LX3 hand cntrl. & #38 dec. motor	**$189**

NEWTONIAN

Model 826C 8" f/6 w/motor, 2" focuser	**$898**
SPECIAL PROMOTION	
Model DS-10A, 10" f/4.5 with motor, 2" focuser	**$775**
Model DS-16AB, 16" f/4.5 w/motor, 2" focuser, Sealmaster ball bearings	**$1875**
8X50mm finderscope w/brackets for DS-10 or DS-16	**$109**

2" DELUXE BARLOW

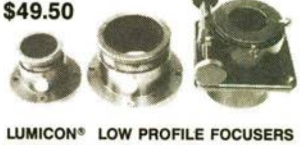
1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. Guide-stars also become much sharper to make guiding easier. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

LUMICON 1.8x multiplier lens	**$235.00**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM
$49.50



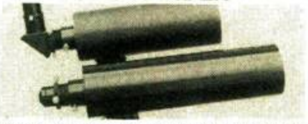
LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$49.50**
LUMICON 2" Helical Focuser 1½" high	**$59.50**
LUMICON Non-rotating Helical Focuser	**$89.50**
2" rack & pinion focuser, only 2" high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2"/1¼" adapter w/48mm filter threads	**$20.00**
2" LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra. The

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER	**$169**
1¼" right-angle 80mm SUPER-FINDER	**$179.50**
1¼" right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼" eyepiece (12X)	**$39**
1¼" Star Diagonal **$39**, Mounting Brackets,	**$37**
1¼" Amici Prism diag. for correct left-right views	**$69.50**

2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for C-80, C-100 refractor	**$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F	**$39.50**
2" Accessory adapter for Comet Catcher, C-6, Meade 310, 320 refractor	**$30.00**
2" adapter for Takahashi E-130, 160	**$59.50**

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WHY IS THE ORION NEBULA BEAUTIFUL?

by Francis Stark

It was 4:40 a.m.

I had just returned to the house from a half-hour spent observing the Orion Nebula for the first time this season. I removed two of the three sweaters I was wearing, as well as my gloves and woolen cap, and I slowly perused the comments in *Burnham's Celestial Handbook:* "awesome," "incredible spectacle," and so on.

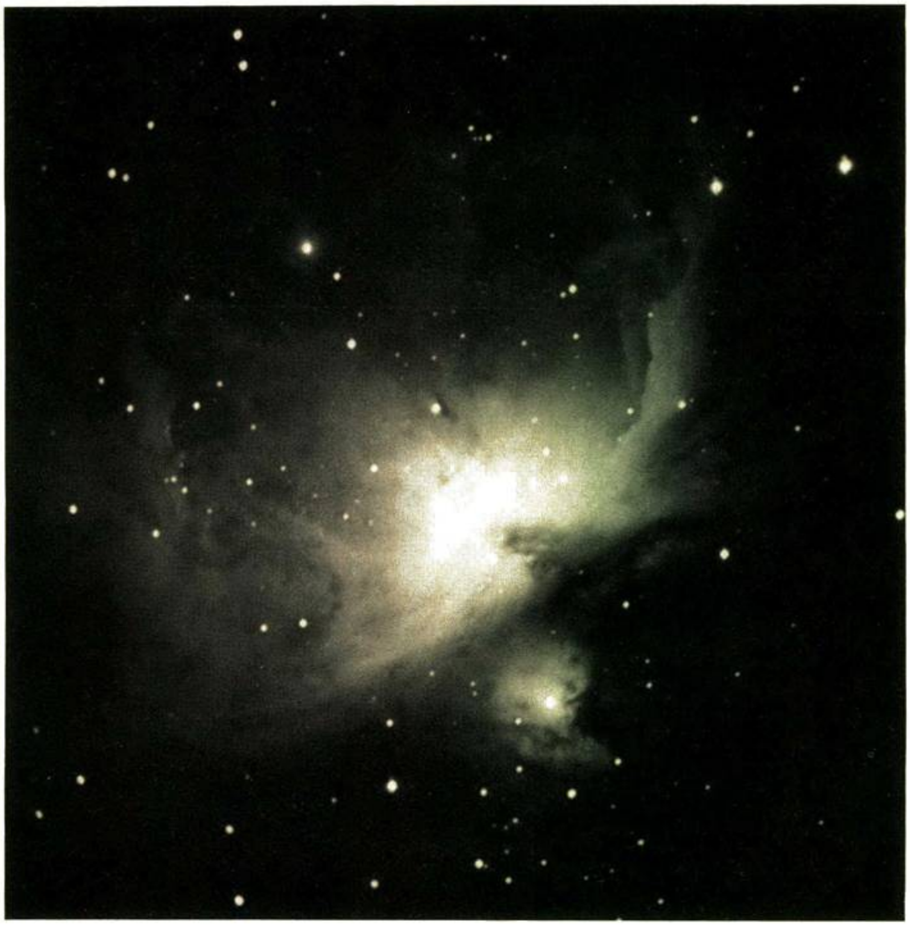
(Some technical details: I was using a Meade LX2 (mostly with a 40mm Plössl and an 11mm Nagler eyepiece), the Moon was 24 days old and low in the East; seeing was only fair. In short, the view of the nebula was good but far from ideal.)

As I read Burnham's commentary I found myself agreeing wholeheartedly with the observations of the various well-known astronomers he quotes. There's no question in my mind that the Orion Nebula is indeed a magnificient spectacle. But for the first time since I bought my first beginner's telescope 30 years ago, one question popped, unbidden, into my mind: *Why* is the Orion Nebula beautiful?

It was just an idle musing at first. Considering the time of the morning and my general physical and mental fatigue, such thoughts are hardly surprising. But I don't think the question is a trivial one; and in any case, it has been on my mind ever since.

The night that prompted the thoughts began misty with light rain. But hoping that the meteorologists might be right for once, I waited for the clouds to disappear. As the night wore on and the clouds remained, I became increasingly frustrated and bad-tempered. (Why is it that amateur astronomers always believe the weatherman who says it will be clear and disbelieve the one who says it won't? Very strange.)

And yet at 4:10 a.m. there I was, bent over my telescope, notwithstanding the



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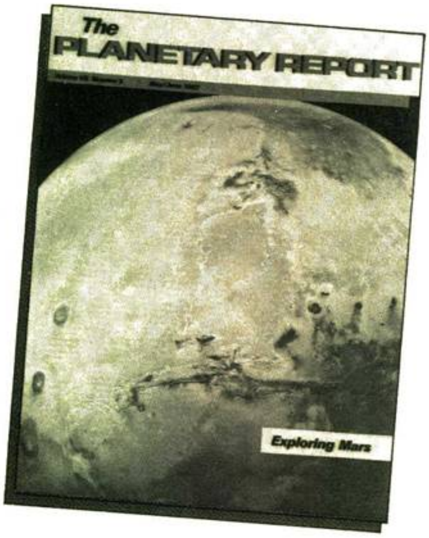

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cold and humidity. Not only did I spend the next half-hour enthralled, I came back into the house both wide awake and relaxed. The Orion Nebula was a magical sight, and I had a great desire to understand how the magic worked.

When looked upon objectively, the nebula is nothing extraordinary — it's a hazy patch of faint, foggy, greenish light, with some brighter and darker areas that can be discerned with a certain degree of patience and perseverance. At best, it resembles an intricately misted portion of an automobile windshield on a wet night — something I don't find the slightest bit appealing.

It's interesting to ask if, given the weather and other circumstances I have described, I would have endured similar conditions to catch a glimpse of Michelangelo's *Pietà* or da Vinci's *Virgin of the Rocks,* fond as I might be of either work. The answer, pure and simple, is no. If the museum were too crowded, the lineups too long, well.... I'd probably reason that the work would still be there tomorrow and I'd go see it another time. And yet for the Orion Nebula, a mere freak of nature, the discomfort had been worthwhile. Why?

It's tempting to explain this by saying that observers have "insider" knowledge and by imputing specialized insights to them. After all, intones the pundit, we amateur astronomers are cognizant of what it is we are observing. We know that the nebula is so many light-years away and of such-and-such a diameter, that it is a chaotic region of dust and gas in which stars, *at this very moment,* are being born. Because we are aware of the processes we are observing, because we imagine that we are able to appreciate the distances and sizes involved, we are awestruck by the phenomenon and therefore find it beautiful. (I've always wondered whether we really *do* have any greater appreciation of astronomical distances than the average individual, to whom all those things up there are just a long, long way away. I doubt it, but that's a discussion for another day.)

I do feel that the knowledge we possess makes it possible for us to appreciate what we are observing more than we would if we were astronomically untutored. But this appreciation is not aesthetic; it's cerebral. It is a finely honed appreciation of the brushstrokes, *if you will, of the technique* — not of the art, not of the real beauty that may be there.

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This is not just a theoretical distinction. After all, when you are on a crowded beach on a scorching summer day, the Sun's appearance does not strike you with awe — despite the fact that its processes (which you understand to some extent) are every bit as intricate as those occurring within the Orion Nebula and are as little understood by the people around you. You may intellectually appreciate the Sun's workings (if you ever thought about it, which I am sure, like me, you mostly do not), but for the time being the Sun is nothing other than a bright ball in the sky. For the time being, at least, you see it the same way that everybody else does.

So what is it that makes the Orion Nebula beautiful?

On a question of aesthetics, it's difficult to arrive at an answer in any kind of logical fashion. But it occurred to me that I might be able to put it to an empirical test.

One evening I was with a friend who very seldom looks through a telescope and whose knowledge of matters astronomical is nil. With the Orion Nebula in the field, I waved at the telescope and suggested she might want to have a look. She gazed at the field for about twenty seconds and turned to me and said — and I quote verbatim — "How incredibly beautiful!"

She stayed at the telescope another ten minutes, attempting to see more detail. This, despite the fact that she had no mental image of what it was she should be seeing, what processes were occurring, where the dark lanes were, or any awareness of the limitations of the instrument and what she might have seen under the best of conditions. She merely found the sight fascinating, in and of itself, without any prior knowledge of what, or where, or how far.

And so without getting really any closer to an answer, we come back to my original query. The nature of celestial beauty was examined at some length in the book *Spaceshots* by Timothy Ferris, also without a satisfactory conclusion. It would appear the Orion Nebula is beautiful because of what it is — and not because I happen to know more-or-less what it is.

It would be pointless to try to list which objects in the sky are beautiful and which are not. Beauty is truly in the eye, and not the brain, of the beholder. And yet each of us has his or her favorites that we delight in showing novices at the telescope. We say casually, "You might find this interesting," while we desperately hope they may feel some of the joy and awe that we feel.

And, sometimes, they do.

REMEMBER YOUR MENTOR

by Larry Hughes

Recently, I took a Friday off for a little mental maintenance. Rummaging in my corner stack of old astronomy items, I happened upon a beat-up green notebook containing newsletters from my first astronomy club in Downey, California.

Opening the dusty old pages was unexpected fun. Despite the passage of over twenty years, the names sprang instantly to life: the characters, the nerds (my name being at the top of *that* list), the observing companions. But the people I remembered most fondly were the ones who had gone out of their way to encourage my love of astronomy. I still think of them as my mentors.

Most of us probably can think of a mentor or two — certainly the first person who let you peer through their telescope. In my case, my dad was the first to give in to the inevitability of my becoming a star wastrel. Although he never showed a significant interest in astronomy, he helped me purchase my first scope and took me out for an occasional observing session.

On one memorable occasion he took time off from a busy schedule to drive me from Los Angeles up to a prime mountain observing site. The drive took two hours, one way. It was bitterly cold outside and I cowered in the car while my dad struggled to set up the telescope. Finally it was all ready to go. I'll never forget those few seconds after he called for the eyepiece case, which was still sitting on my dresser back in L.A. I was very grateful that my dad, a minister, lived his faith as well as he preached it. The ride back to town was long enough.

But the astronomy club was the place where I learned about the basics of amateur astronomy. Two club members were particularly important to me. Jim Kissick, a structural engineer at North American Rockwell, was always there to help get a kid started. He was the one who loaded his van with kids and scopes for the trip to pristine skies at Mt. Pinos. He was the one who treated us to a meal, or would point us in the right direction in observing, or would help us design a better telescope. And I remember how his new pride, an innovative new fork mount, suddenly ended up at my house to give my new 12 1/2 inch tube assembly an extended trial run .

The other club member, Joe Perry, was a real character. There are three things I remember when I think of Joe: energy, spelling, and optics. Joe had so much energy that half the time I was sure he would hurt himself, just out of pure enthusiasm. That energy probably led to his legendary spelling: he typed like a machine gun, and when he hit a wrong key, why, he'd just keep re-spelling the word until it landed close to the Webster version. His letters read virtually like a foreign language.

But above all, Joe was a tireless amateur optician, working up to five mirrors at a time. Back in the days when a 10-inch scope was the biggest gun at a star party, Joe plunged right into a 32-inch Ritchey-Chretien Cassegrain. Many of us in the club cut our teeth in mirror-making under the guidance of Joe Perry. Today, when I push a piece of glass across a recalcitrant lap, I think of Joe and somewhow work a little harder.

In 1989 Joe, Jim, and I had a mini-reunion at the Riverside Telescope Maker's Conference. This annual "binge" of observing, exchanging ideas, and scavenging the swap meet makes for a great time. But I remember the '89 meeting best for seeing two friends again after so many years. Joe was as energetic as ever, and Jim as affable. We shared a good laugh as Joe loaded down some miserable old mount with a rats-nest of video cameras and wires, only to lose his power supply before getting a steady image.

Still vigorous at heart but getting along in years, Jim was reluctant to go observing at night, fearing a fall in the dark. So he took Joe's arm on the left and mine on the right, and the three of us slowly worked our way up Telescope Alley to observe to our heart's content. Jim was clearly pleased to be out observing again. "This is the first time I've been able to observe in years," he said as we waited in line for the next celestial splendor. It was good to give back just a little.

I took the opportunity to thank Joe and Jim for the help they gave me in getting started in amateur astronomy. Today, I cannot possibly go star-gazing without being reminded of their contributions to so many of my generation.

If you had a mentor, and if he or she is still around, why not drop them a letter to let them know how much you appreciated their help and friendship?

And then it'll be *your* turn to pass on the gift to the next generation. ☐

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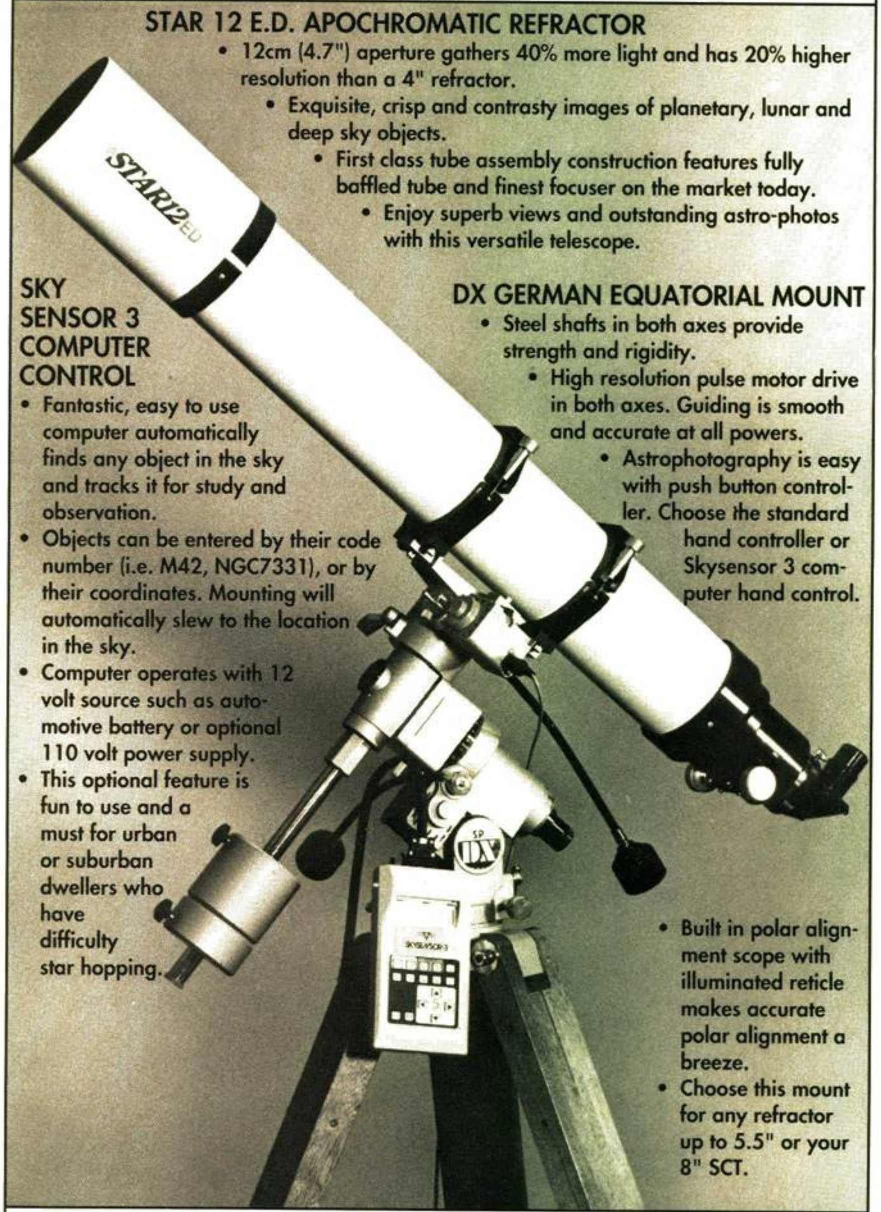

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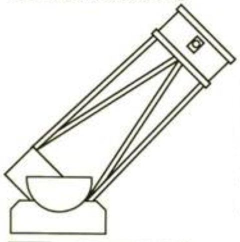

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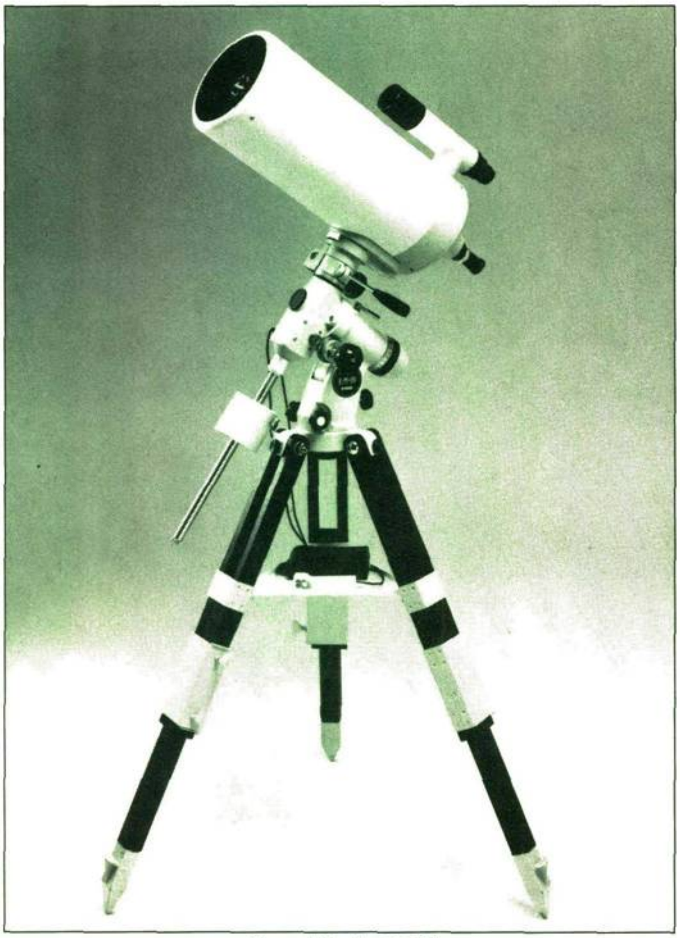

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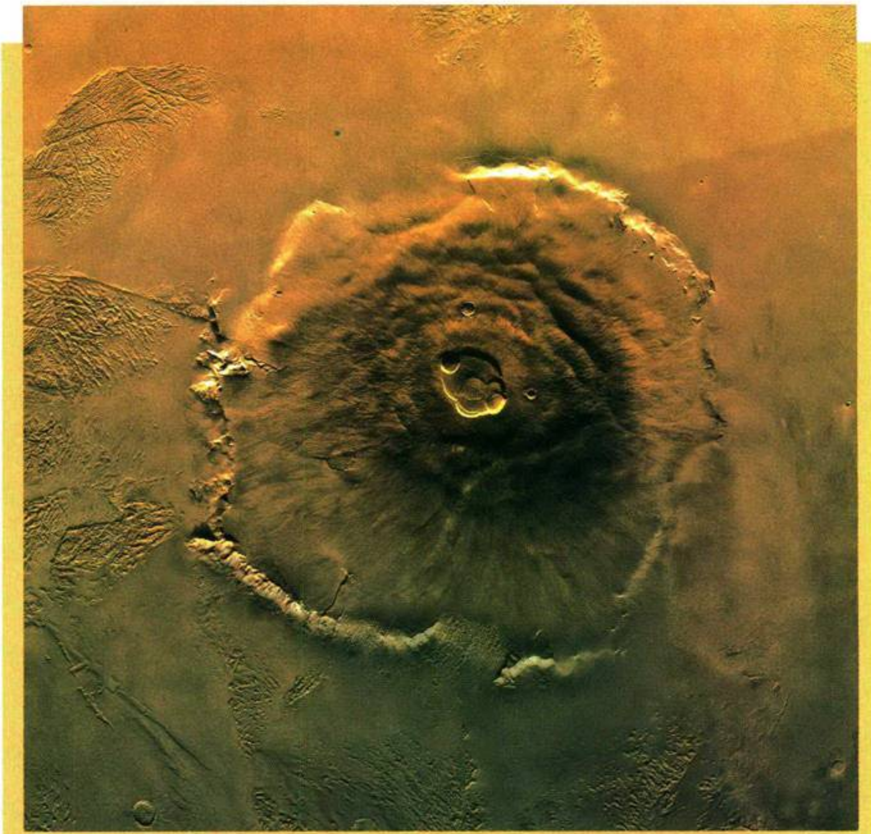


The Martian volcano Olympus Mons is the largest known in the solar system. It spans 600 kilometers across, the summit lies 27 kilometers above the plain, and the scarp around its base is up to 6 kilometers high. This image was recently produced by Annie Allison and Alfred McEwen of the U. S. Geological Survey in Flagstaff, Arizona, combining a Mars medium-resolution digital image model (part of an on-going Mars-mapping project) and low-resolution color observations.

The United States Congress has approved start-up funding for two new telescopes destined for the summit of Mauna Kea on the island of Hawaii. The 1991 Federal budget included $4 million to begin work on an 8-meter optical telescope and $2.1 million for initial funding of a submillimeter-wave telescope.

The 8-meter telescope will be operated by the National Optical Astronomy Observatories as a national telescope accessible to the entire U.S. community of astronomers. It is the first in a pair of 8-meter telescopes, the second to be located in Chile on a peak near the Cerro Tololo Inter-American Observatory. The twin telescopes will give astronomers unprecedented views of both the northern and southern hemispheres of the sky. Each telescope will use a single mirror 8 meters across (more than 25 feet) with a light-gathering power more than two and a half times greater than that of the Mount Palomar 200-inch. Construction of the Northern 8-meter Telescope is expected to begin in early 1993 with a projected cost of $80 million.

The other new telescope that won start-up funding, the Smithsonian Astrophysical Observatory's Submillimeter Array Telescope, will consist of a set of six or more dishes, each about 20 feet across. The array will be sensitive to the wavelength band between infrared and radio waves. Two submillimeter telescopes are already situated on Mauna Kea. However, the new Submillimeter Array will have twenty times the resolution of these existing instruments. As Robert McLaren, associate director for the University of Hawaii's Institute for Astronomy, explained, "The signals from the dishes will be combined electronically, or by fiber optics, to achieve the image detail equivalent to that of a telescope nearly one-third of a mile across. It will give astronomers a view of the universe at submillimeter wavelengths with a resolution comparable to that intended for the *Hubble Space Telescope* at optical wavelengths." The cost of the Submillimeter Array is expected to be about $50 million. The final site has not been selected, but according to Donald Hall, Director of the Institute for Astronomy, "The early tests are confirming the superb qualities of Mauna Kea for submillimeter astronomy. I am confident that Mauna Kea will win out, just as it did in the selection of the site for the Northern 8-meter."

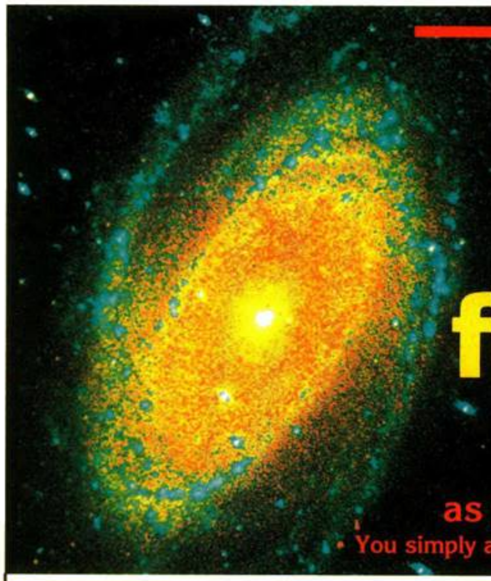
IMAGING THE MILKY WAY'S CENTER

Three European astronomers have recently imaged the center of the Milky Way and think they have identified an optical counterpart to the radio source located there. The Galactic center, which lies behind a thick veil of interstellar gas and dust, has never been seen before at any wavelengths shorter than those of radio waves. (See "Strange Doings at the Milky Way's Core," October 1990.)

Hans Zinnecker, Michael Rosa, and Andrea Moneti used the European Southern Observatory's 3.6-meter New Technology Telescope (NTT) at La Silla, Chile, to get the image. But they also needed a clever strategy to overcome several roadblocks lying in their path.

Astronomers assume that the Galactic center emits most of its energy at fairly short (blue) wavelengths, as do most other high-energy objects. But the interstellar clouds that lie between us and the center absorb blue light very strongly, letting through only about one-trillionth of what is emitted at the center. Thus, even with the NTT, astronomers cannot collect enough blue light to see into the core. A much higher percentage of the infrared radiation released at the center passes through the interstellar clouds. But if the center is blue, it would not emit much infrared radiation to begin with and thus could not be seen at those wavelengths either.

The astronomers reasoned that their



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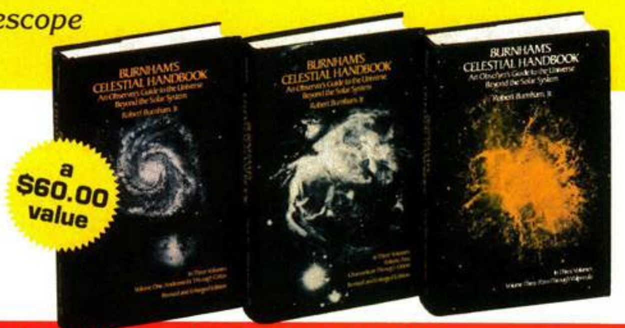
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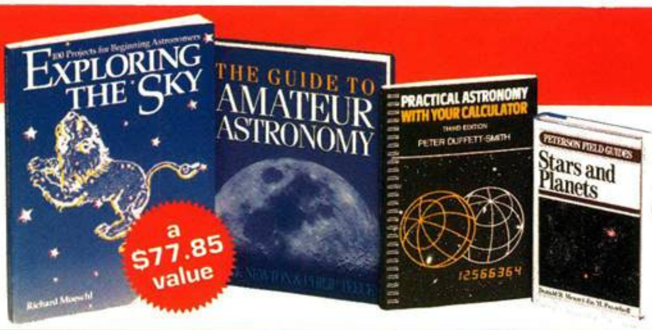
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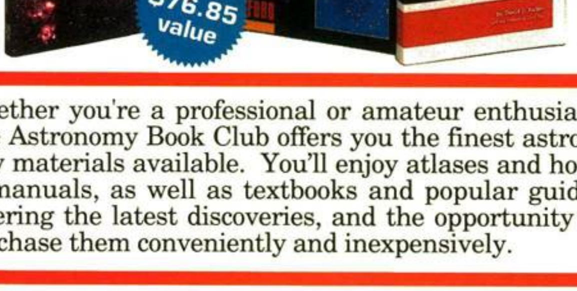
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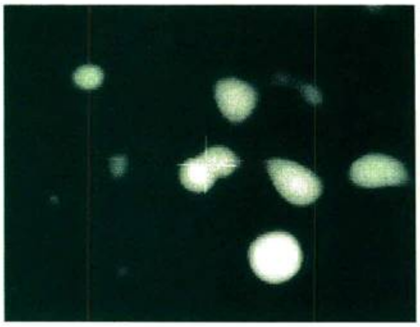
best hope of imaging the center would be at a wavelength in between that of blue light and infrared radiation. They chose a filter that let through light with wavelengths between 8,500 and 11,000 angstroms, in the near-infrared part of the spectrum just beyond red light.

Their work was not yet done, however. The resulting image contains two bright objects, one of which is a 17.6-magnitude, infrared-emitting object that lies near the Galactic center's position but is not directly connected with the center. The image of that star appeared slightly elongated, indicating that some fainter objects were also present.

To find out what lay hidden in the glare of that star, the astronomers subtracted the round image of the other bright star in the frame from the elongated star image (the result is shown at right). What they found were two previously unknown starlike objects located very close to the position of the radio source at the Galaxy's center, which is indicated by the cross.

The objects, designated GZ-A and GZ-B, lie 0.3 and 0.5 arcseconds, respectively, from the Galactic center. Both lie well within the uncertainty in the radio position of the center. Because GZ-A lies so close to the center and no infrared radiation has been detected from it, implying that it is a blue object, the astronomers strongly suspect that this is the optical image of the Galaxy's center.



WHAT LIES AT THE HEART of the Galaxy? A small object (shown to the lower left of the cross) that has been photographed for the first time by astronomers using the New Technology Telescope. See the accompanying story for more details. ESO image.

The question of what the object is, however, remains unanswered. From its brightness and size, GZ-A could be a very compact cluster of about 15 O-type supergiant stars. The observations are also consistent with a black hole surrounded by an accretion disk of hot gas. Now that the center has been identified optically, spectroscopic observations should be able to differentiate between the two possibilities and reveal once and for all what lies at the core of the Milky Way.

Space News

ASTRO-1 FLIES AT LAST

It was a look at the universe that astronomers had been anticipating for years. In early December, NASA's long-delayed *Astro-1/Spacelab* observatory with its complement of four telescopes swept into orbit on board the shuttle *Columbia* and gave Earthbound astronomers a tantalizing peek at the ultraviolet and x-ray universe.

Twenty-four hours a day for nine days, stubborn teams of astronomers based at the Marshall Space Flight Center in Huntsville, Alabama surmounted a string of *Spacelab* and *Space Shuttle* problems to make 135 successful observations with the $150 million array of telescopes.

"We accomplished some science. It wasn't as much as we wanted, but we packed the schedule as full as we could," said mission scientist Ted Gull. Considering the problems that plagued the *Astro* mission — from a balky automatic pointing system to lint-clogged *Spacelab* computer terminals — it's a wonder that the astronomers were able to observe at all. But the relatively small telescopes in the shuttle cargo bay, when accurately pointed and commanded, performed exquisitely.

Astro's three ultraviolet telescopes and one x-ray telescope looked at objects ranging from the Jovian moon Io to emission nebulae, vast clouds of interstellar dust and gas where new stars are born. Literally as the astronauts were closing the doors on the telescopes at the end of the mission, astronomers also glimpsed Comet Levy. They hope to learn if the dust in comets resembles the dust between stars, indicating that comets are indeed samples of the stuff that forms planets. A surprising finding was that interstellar dust, thought to be made of graphite, seems to *absorb* starlight rather than scatter it as previously believed. This means that interstellar dust might provide the critical cooling required to allow clouds of gas to collapse into newborn stars. The orbiting observatory also glimpsed x-ray emissions from a quasar that appeared to be generated by a swirling disk of material surrounding a black hole.

"With every observation we were pushing into new territory," commented Arthur F. Davidsen, a Johns Hopkins astronomer who led the development of the *Astro* telescope that sampled extremely short ultraviolet wavelengths. According to University of Wisconsin-Madison astronomer Arthur D. Code who led the team that built the telescope designed to look at polarized ultraviolet light, "Since we never knew about ultraviolet polarization before, every photon that we collected was something new."

Astro scientists are certain they will fill in some new pieces to the celestial puzzle using observations made by *Astro-1.* However, nine days in space is a short time, not enough to look at all the objects astronomers would have liked. The hope is that the *Astro/Spacelab* package will fly again, allowing astronomers to observe still more of the universe during flights of *Astro-2* and *Astro-3.* Those hopes were dimmed during the mission when NASA released its shuttle manifest for the next two years, a schedule that did not include any reflights of *Astro.*

"We've certainly shown that these are real bang-up instruments," said Wisconsin astronomer Christopher Anderson. "They did things that had never been done before and there's another half of the sky that we'd like to look at. They really do deserve to fly again." — *Terry Devitt*

GAMMA RAY OBSERVATORY GOES UP IN APRIL

The next in the series of four Great Observatories, NASA's *Gamma Ray Observatory,* is now scheduled for launch in April by the space shuttle *Atlantis.* The *Hubble Space Telescope,* designed for work at visible and ultraviolet wavelengths, was the first in the orbiting observatory series. The *Advanced X-Ray Astrophysics Facility* and the *Shuttle Infrared Telescope Facility,* both scheduled for launch later in the

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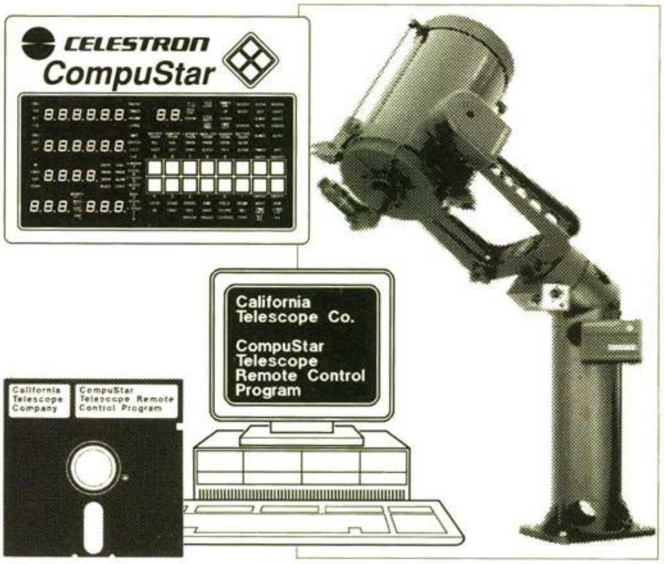
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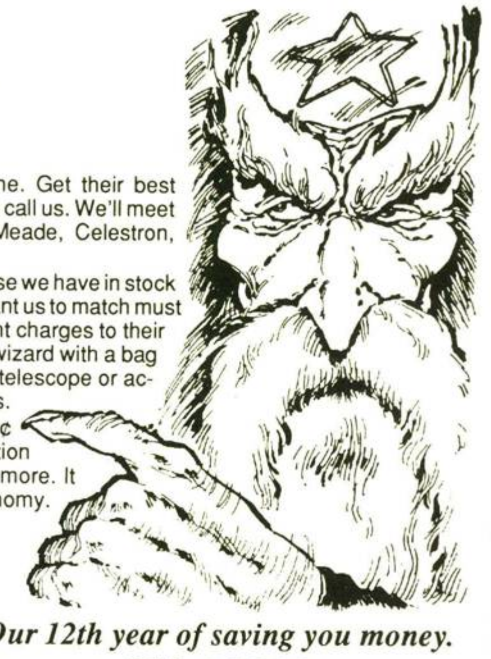

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decade, will complete the constellation of NASA's orbiting telescopes. Together, the four telescopes will allow astronomers to view the universe from the low-energy infrared to the high-energy gamma ray bands with telescopes unhampered by Earth's atmosphere. The launch plans for the *Gamma Ray Observatory* were announced in December along with NASA's schedule for Shuttle launches from 1991 to 1993. Over the next three years, NASA plans 27 *Space Shuttle* launches, 19 of which will be for science missions. Space science missions for the remainder of 1991 include the Space Life Sciences mission in May, the *Upper Atmospheric Research Satellite* in November, and the first International Microgravity Laboratory *Spacelab* mission in December. The newest space shuttle, *Endeavour,* will make its maiden flight in May 1992 on a mission to rescue a stranded INTELSAT communications satellite.

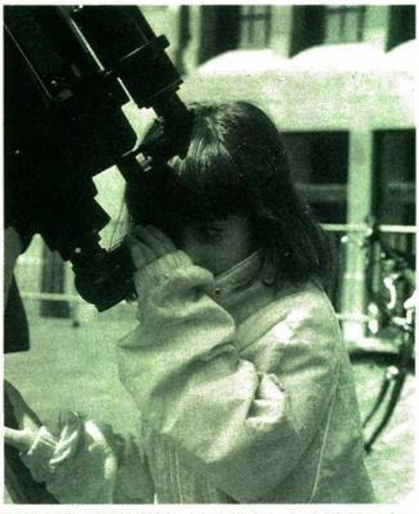
NASA also announced thirteen launches of expendable rockets over the next three years, including the Delta II launch of the *Extreme Ultraviolet Explorer* in August 1991 and the *Geotail* satellite in July 1992. The next planetary probe, NASA's *Mars Observer,* will be launched by a Titan III rocket in September 1992.

Amateur News

WHERE WILL YOU BE ON APRIL 20?

Astronomy clubs around North America, indeed around the world, are preparing for International Astronomy Day, 1991, to be held April 20. Through the efforts of club members, tens of thousands of people will be introduced to the hobby of astronomy and to the wonders of the night sky.

Held annually since 1973, Astronomy Day takes the form of special events, talks, displays, films, star parties, and other activities hosted by clubs, often in cooperation with local museums, planetariums, nature centers, colleges, and parks authorities. One of the themes of Astronomy Day is "taking astronomy to the people." Events are often held where people congregate. Indoor shopping malls are prime sites. Some of the activities and displays that clubs have organized in the past for malls include astronomy art contests, telescope displays, outside solar observing, slide-tape and video programs, hands-on computers, scale models of the solar system, portable planetariums and, increasingly, displays on the effects of light pollution.



PUBLIC VIEWING highlighted 1990's Astronomy Week activities organized by the Royal Astronomical Society of Canada's Toronto Centre. Photo courtesy John Ginder.

Events at museum and observatory sites often center on telescope viewing, special planetarium shows, film festivals, and guest speakers. Some clubs have been particularly creative at putting together activities. Unique ideas we've seen in the last few years include

— A Moon gravity simulator (Wilderness Center Astronomy Club, Wilmot, Ohio). This was a harness and pulley system that allowed a person to experience the effect of weighing one-sixth their normal weight.

— Talks by famous astronomers of the past (Bays Mountain Amateur Astronomers, Kingsport, Tennessee). Members dressed up as Newton, Galileo, and Herschel and gave talks to the public.

— The grinding of a 40-inch mirror (Lehigh Valley Amateur Astronomical Society, Allentown, Pennsylvania). Public displays of their mirror in progress helped publicize their observatory project and the need for legislation to protect their dark site from light pollution.

— Programs for people with disabilities (Charles Hayden Planetarium, Boston). Astronomy talks were accompanied by sign language interpreters. The Planetarium also had tactile exhibits for people with visual disabilities.

— Astronomy Week (Toronto Centre, R.A.S.C.). In 1990, the City of Toronto declared April 21 to 28 "International Astronomy Week." A 12-page booklet produced by the Centre provided information on lectures and star parties held at nine sites around the city throughout the week.

To help organizations host Astronomy Day events, the Astronomical League has put together a 120-page handbook full of suggestions for activities and advertising techniques. The *Astronomy Day Handbook* is sold for the cost of printing and postage ($7 in the United States, $8 outside the U.S., $10 outside the U.S. for air mail, payable in U.S. funds). Organizations interested in a copy should write to Gary Tomlinson at the Chaffee Planetarium, 54 Jefferson S.E., Grand Rapids, MI 49503; (616) 456-3987.

Where will you be on April 20? If you are not helping to organize an Astronomy Day event, be sure to at least attend one. Check with your local club or planetarium to learn what's happening in your area. — *Gary Tomlinson, Astronomy Day Coordinator*

PUT YOUR CLUB ON OUR LIST

Each year in the May issue, ASTRONOMY publishes a list of astronomy clubs in North America. To compile this information, we send out questionnaires to clubs in early January. If your club was not on last year's list or did not receive a questionnaire this year, please let us know. Drop us a note telling us about your club: its mailing address, who prospective members should contact, phone number for the contact person, number of members, year the club was founded, whether you have an observatory, what size telescope it houses, and information about any regional star parties your club is planning for the May to October period.

Please send your club's vital statistics as soon as possible to Alan Dyer, ASTRONOMY Magazine, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187. You can also FAX us at (414) 796-0126 or phone us at (414) 796-8776. □

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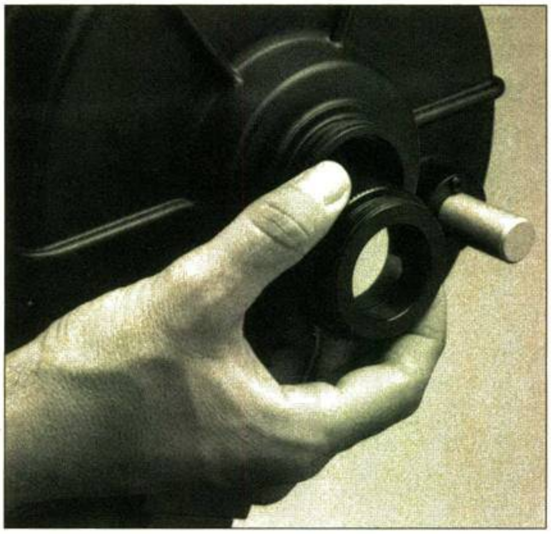

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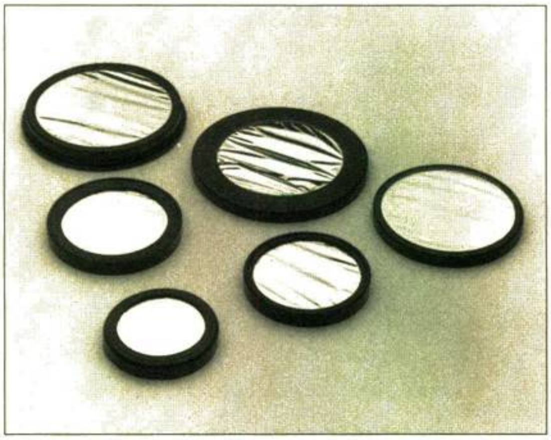

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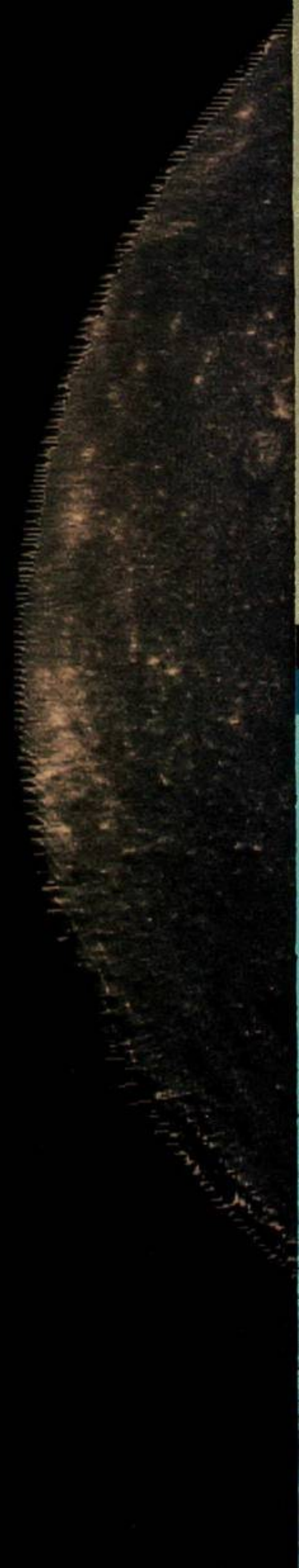
GALILEO BOUND FOR JUPITER

Galileo's Flyby of Earth and the Moon

Lightning whistlers, icy clouds, and a largest-ever lunar basin are just three of the new results that emerged from Earth's first encounter with an interplanetary spacecraft.

by Robert Burnham

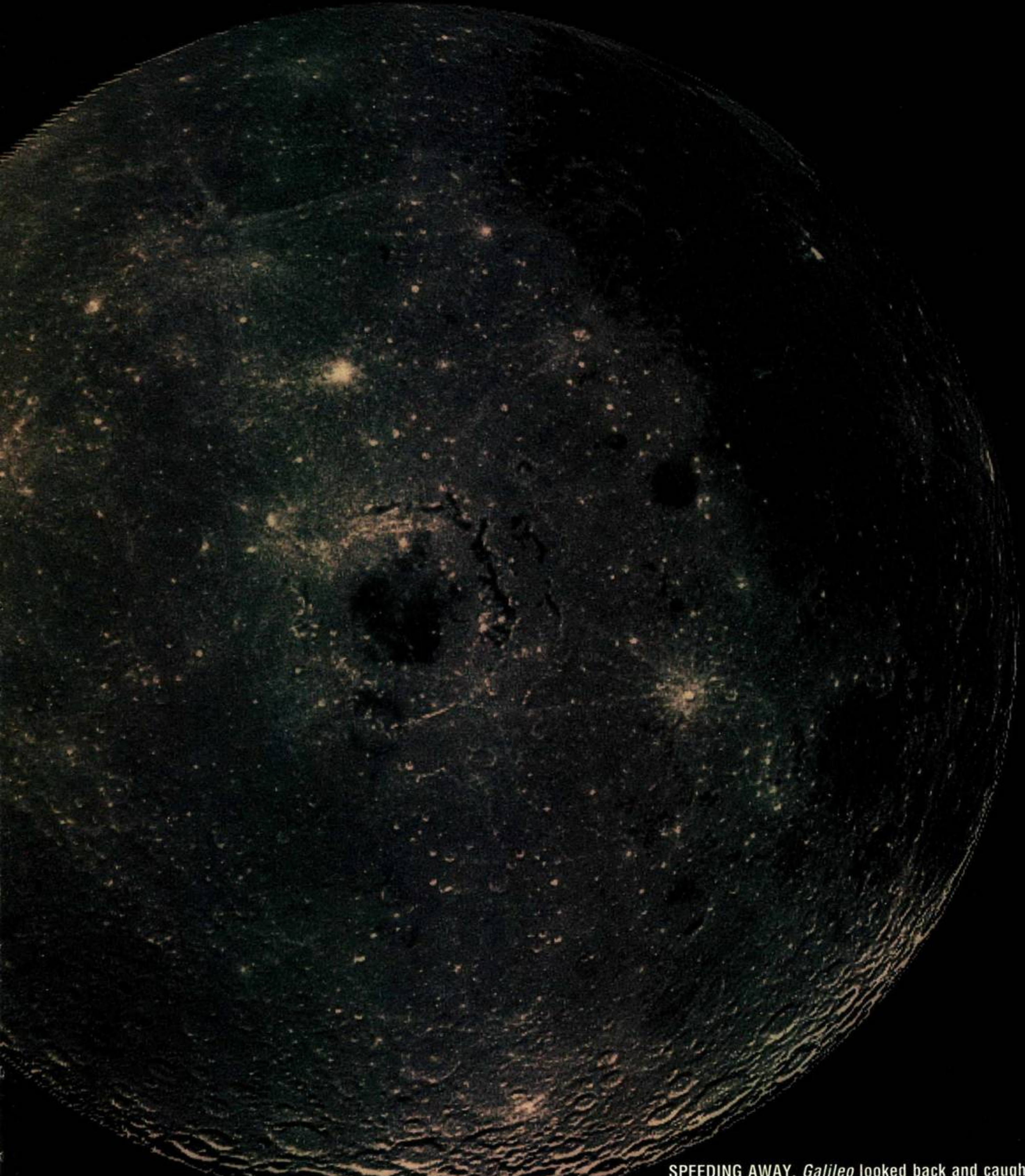


On December 8, 1990, fourteen months after launch aboard the space shuttle *Atlantis, Galileo* was making the first of two Earth flybys necessary to send it to Jupiter, where it will arrive in late 1995.

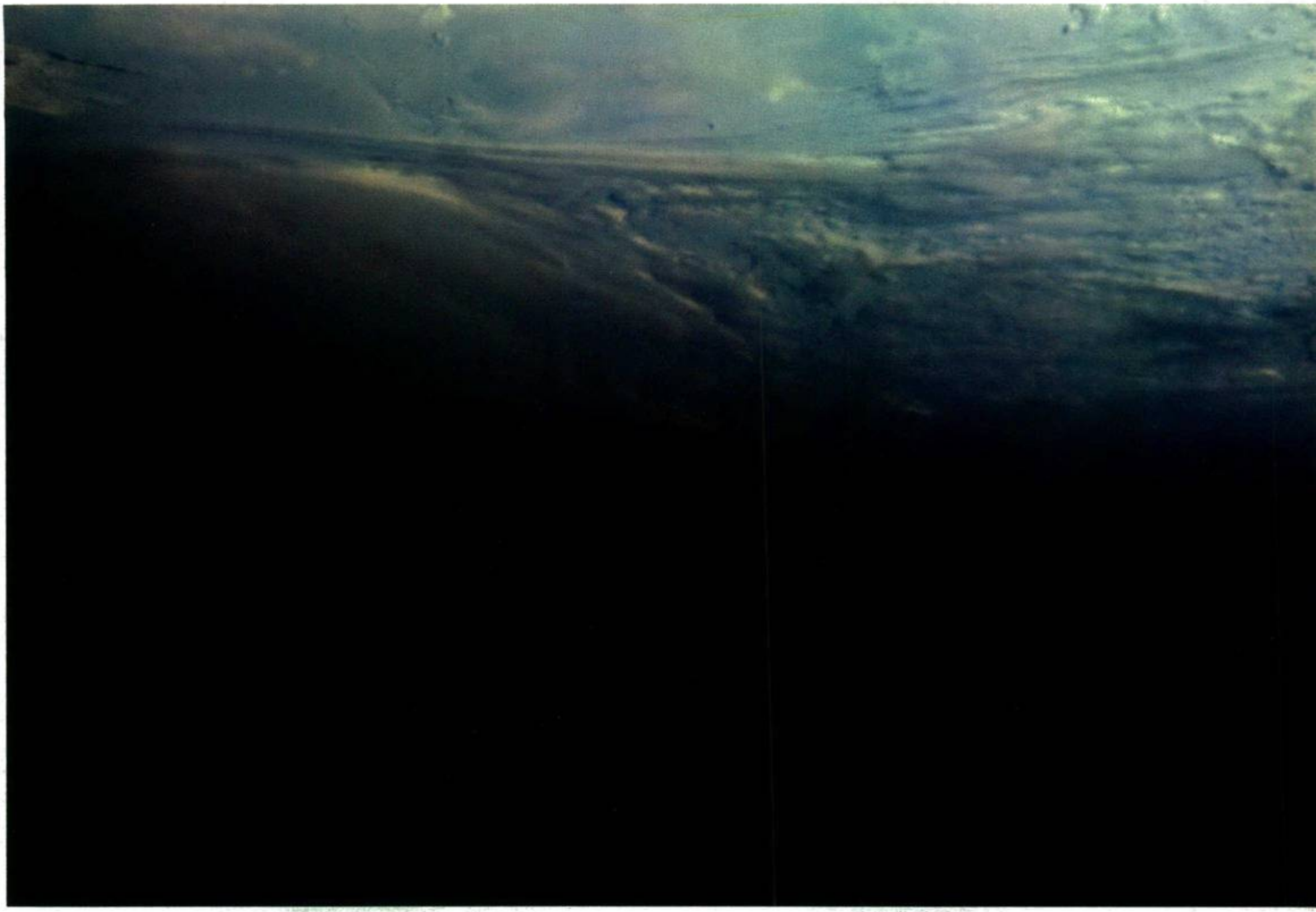
Galileo wasn't supposed to take such a roundabout trip. But today few mission scientists are complaining.

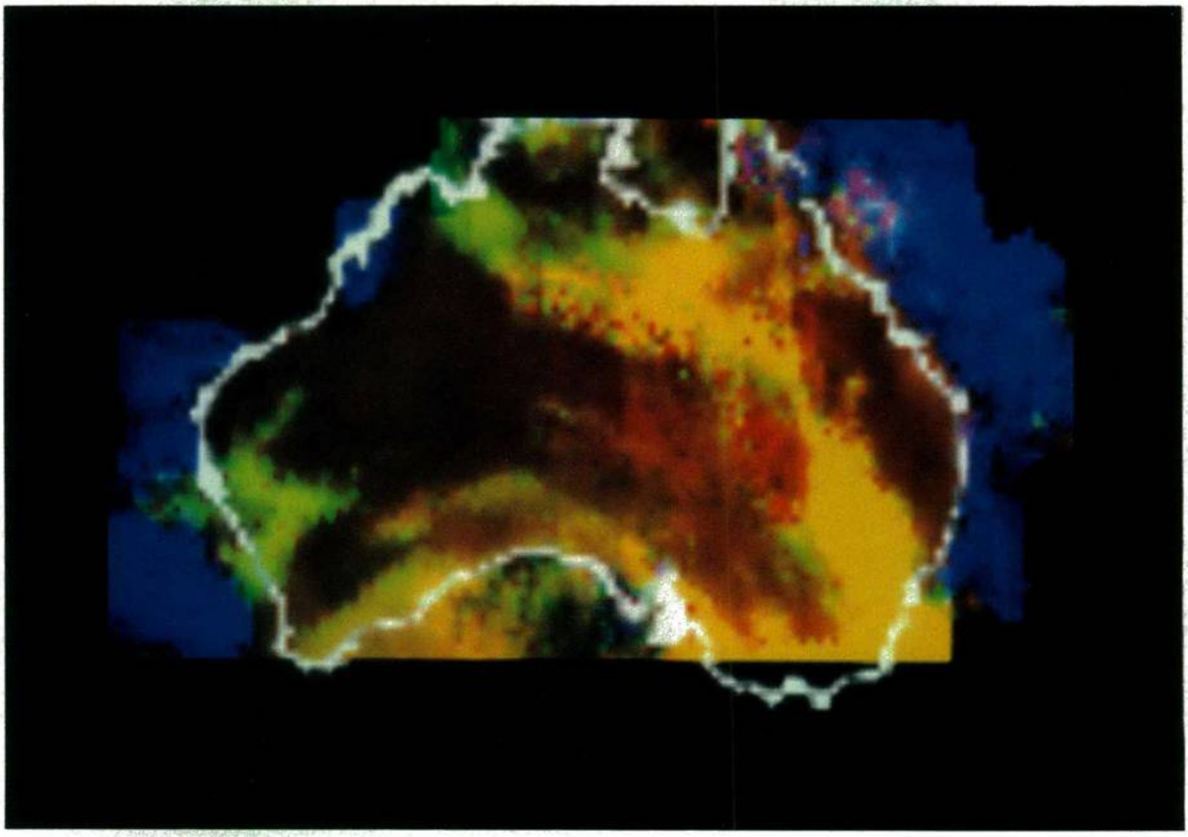
"The long flight means we won't have a *Hubble* happen to us," commented one. "They had to perform their checkout in a blaze of publicity. We get five years and half a dozen practice flybys to get the kinks ironed out: two of Earth and the Moon, one of Venus, and two of asteroids. The shakedown cruise really helps."

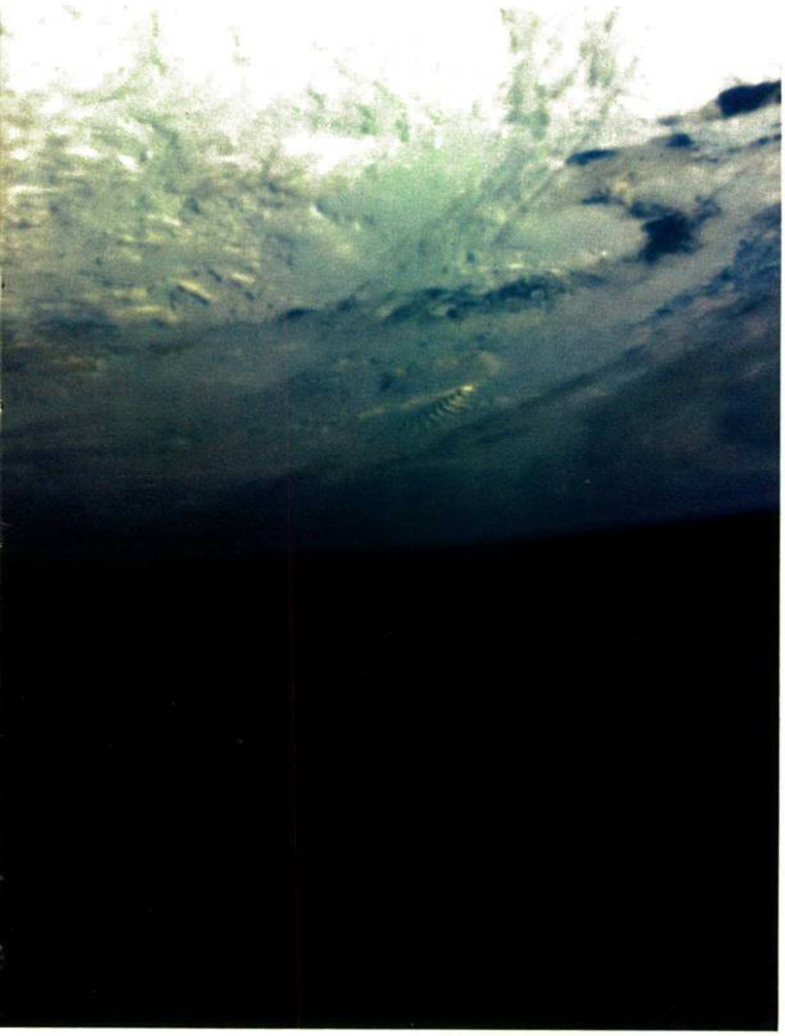
The Venus encounter happened on February 10, 1990. The results, stored on *Galileo's* tape recorder, were played back just before the Earth encounter and will be featured next month in ASTRONOMY.



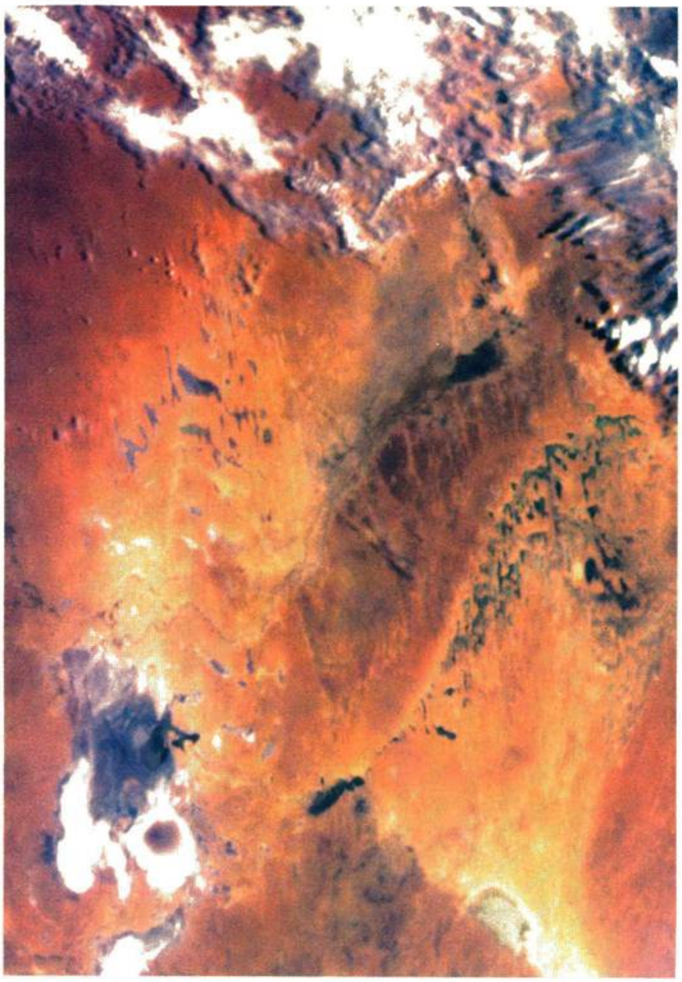
SPEEDING AWAY, *Galileo* looked back and caught Mare Orientale in its lens (above) while at left, South America and Antarctica share the spotlight. The flyby let scientists calibrate their instruments on Earth and explore unmapped lunar regions.







LAYERS OF CLOUD etch the limb of planet Earth, in this view taken by *Galileo's* camera looking north over Antarctica. In corresponding NIMS data, evidence for high clouds may impact what we know about the "ozone hole."



RUDDY DESERTS SPRAWL across central Australia in this composite image taken by *Galileo.* At lower left is Lake Erye, a salt lake lying below sea level and nearly dry in this image.

Approaching Earth from the night side, Galileo flew down the magnetotail. "Galileo was extremely lucky," says Margaret Kivelson of UCLA, the principal investigator on the magnetometer team. "On its way in, it sailed through a very disturbed region of the type that dumps electric currents into the upper atmosphere. *Galileo* was moving much faster than most spacecraft that have investigated these regions, so we're getting a much more instantaneous look."

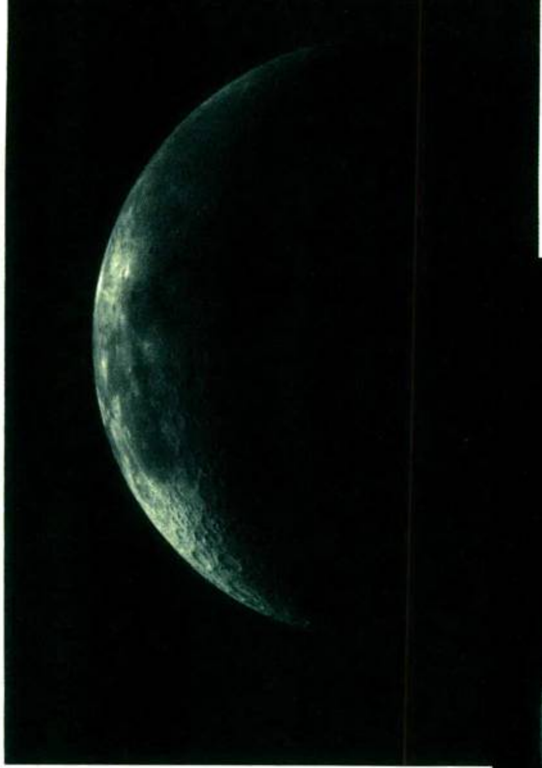
One *Galileo* result came as no surprise. "We found evidence for life on Earth," boasts Robert Carlson of NASA's Jet Propulsion Laboratory with tongue in cheek. He is the principal investigator on the Near Infrared Mapping Spectrometer, (mercifully) called NIMS for short. The NIMS, a combination of a spectroscope and a camera, makes images of objects in many wavelengths (colors) more or less simultaneously. When the instrument's scientists examine how bright a region on a planet or moon looks in various colors, they can usually pin down closely what it is made of.

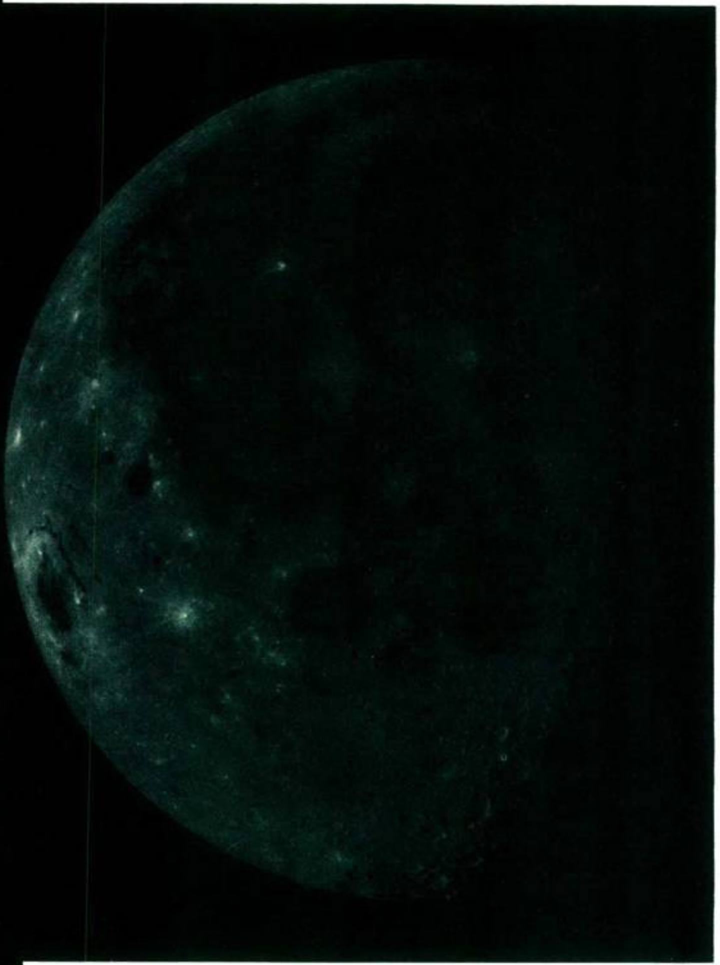
THICK CLOUDS MAKE YELLOW STREAKS while thinner ones are greenish in this false-color image of Australia from *Galileo's* infrared spectrometer. The pink area marks where algae and coral lie just under the ocean surface near the Great Barrier Reef (upper left).

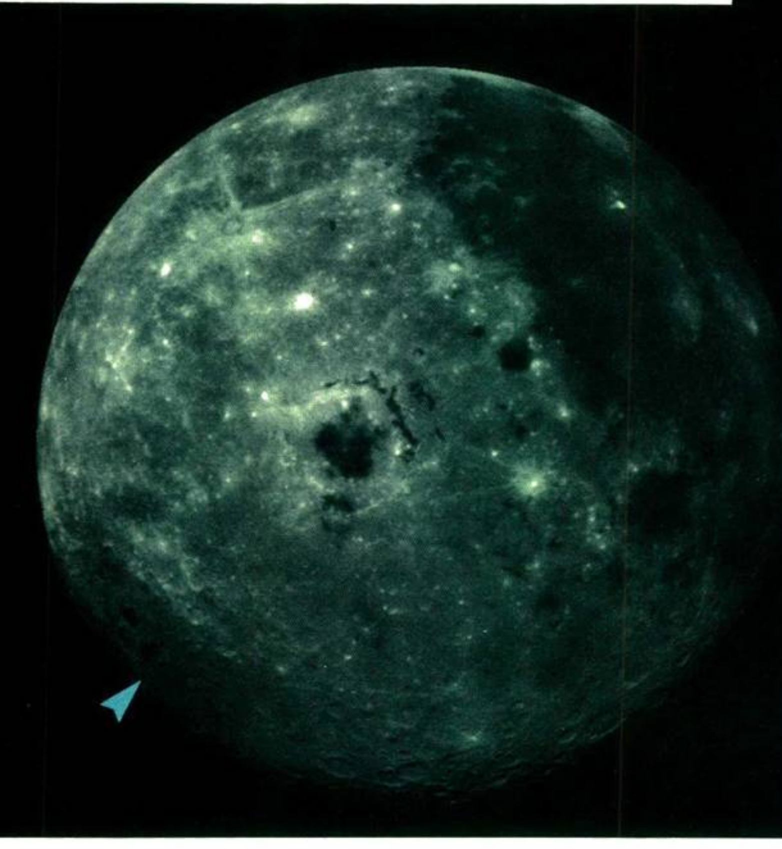
According to Carlson, evidence for life on Earth comes mainly from the amounts of nitrous oxide, methane, and molecular oxygen NIMS detected. These are all gases that readily decompose or combine with other substances. Their presence on Earth means, therefore, that either *Galileo* just happened by at a time when they all were abundant — or that something, in other words, life, is constantly producing them so they exist in abundance.

NIMS also focused its attention on our neighbor, the Moon. It mapped broad areas of surface composition with coarse (100 kilometer) resolution. Among its results is the interesting fact that the impact which created Copernicus punched through the mare basalts and unearthed the underlying highlands material. This is shown by the spectral differences between the mare and the material in the Copernicus ejecta blanket, which NIMS showed are quite different in composition.

Some of *Galileo's* most interesting findings came from its camera, a CCD detector with a battery of special filters to isolate specific colors. Before the flyby,







A NEW LOOK AT AN OLD MOON — only the *Galileo* spacecraft could have taken images showing such familiar features from these unearthly perspectives. (Note the new large basin to the south and west of Mare Orientale.)

scientists expected to use the camera's color sensitivity to find rocks from the lunar mantle exposed in the ejecta around Mare Orientale, a large impact basin on the Moon's western limb. Mare Orientale is 1,000 kilometers across and the zone of fractured rock ought to extend into the mantle, yet the multiband imagery showed that Orientale is all highlands material. No mantle materials, or at least no large amounts of it, are to be seen.

Galileo also found the largest known impact basin yet. Hinted at in older photography, this basin spans some 2,000 kilometers, with one rim close to the lunar south pole and the other reaching the crater Aitken.

"This big basin," says James Head III of Brown University and a member of the imaging science team, "dug down to the mantle and brought up iron-rich material. Its mare-type flooding was later buried under ejecta from Mare Orientale. It pushes back by several hundred million years our date for the earliest episodes of mare flooding."

Planetary scientists are now poring over the rich harvest from *Galileo's* lightning flyby. Two years from now, on December 8, 1992, *Galileo* will return. This time it will look into the Moon's polar regions, territory that's still unexplored. Meanwhile, next up is asteroid Gaspra, due for a visit from *Galileo* on October 29th. ☐

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Tracking the Great White

Last autumn Saturn's normally featureless clouds were disrupted by an immense white spot. It was the biggest Saturnian storm to appear in fifty-seven years.

by Alan Dyer

Alberto Montalvo is a determined amateur astronomer. Every clear night he sets up his 12.5-inch reflector in the driveway at his Los Angeles house and studies the planets. On September 24, 1990, Montalvo turned his scope toward Saturn and expected to see what he'd seen for fifty years, a bland planetary disk marked only by subtle cloud bands. What he actually saw surprised him. "I could not believe my eyes. I saw a bright white spot on the disk. It was like a flashlight, five or six times brighter than the rest of the planet." Familiar with Saturn's past history, Montalvo knew he was witnessing a rare event.

A thousand miles away in Las Cruces, New Mexico, another dedicated amateur, Stuart Wilber, was also peering at Saturn that same evening. He, too, realized that Saturn was displaying one of its rare atmospheric spots. Wilber quickly reported his observation to the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts. Being the first in, Wilber's report is considered the official discovery observation and by tradition from previous spots, the 1990 Great White Spot became informally known as Wilber's Spot.

Montalvo, forever the cautious observer, waited until he saw the Spot again three nights later to confirm his observation and make a report. As a result, despite the fact he was among the first to see it, he missed the opportunity to have the Saturn storm named Montalvo's Spot.

The Spot Spreads Out

By early October the word was out, spread through telegrams, phone calls, FAXes, computer bulletin boards, and club newsletters. Astronomers around the world were studying a Saturnian face that few had seen before. The Great White Spot appeared as a brilliant blemish on the equator of Saturn just above the area where the rings crossed the disk. Every third night Saturn's rotation brought the Spot into view. It was an unmistakable feature in even the smallest backyard telescope. The Spot is thought to have been composed of crystals of ammonia ice swept to the top of the cloud deck from a deeper atmospheric layer. It appeared bright because the ice crystals were fresh and untainted by reactions with sunlight that yellow longer-lived material.

The Spot was a rare event. The last time a large White Spot appeared on Saturn was in 1960, but that feature was small in comparison to the storm the 1990 Spot developed into. Astronomers had to dig back in their logbooks to August 1933 to find records of a Spot similar to 1990's. "Astronomers throughout the world were agog today as the huge spot began to spread slowly over the face of the planet. The spot...covers approximately one-sixth of the surface and is oval in shape and white in color." That was how one newspaper report of the day described the 1933 Spot, a description that could also apply to the 1990 Spot.

For about three weeks after its initial sighting, the 1990 Spot remained a distinct oval cloud. In early October, the storm center displayed a series of multiple brightenings and began to develop an eastward-pointing tail. Starting on October 10, the Spot became twisted and pulled apart by the 1,000 mile-an-hour Saturnian winds. The oval lost its identity as it stretched into a band arcing around the planet's equator. Part of the bright ammonia clouds migrated north and spread completely around the planet, while material at the source latitude of +4° remained confined to a region on one side of the planet.

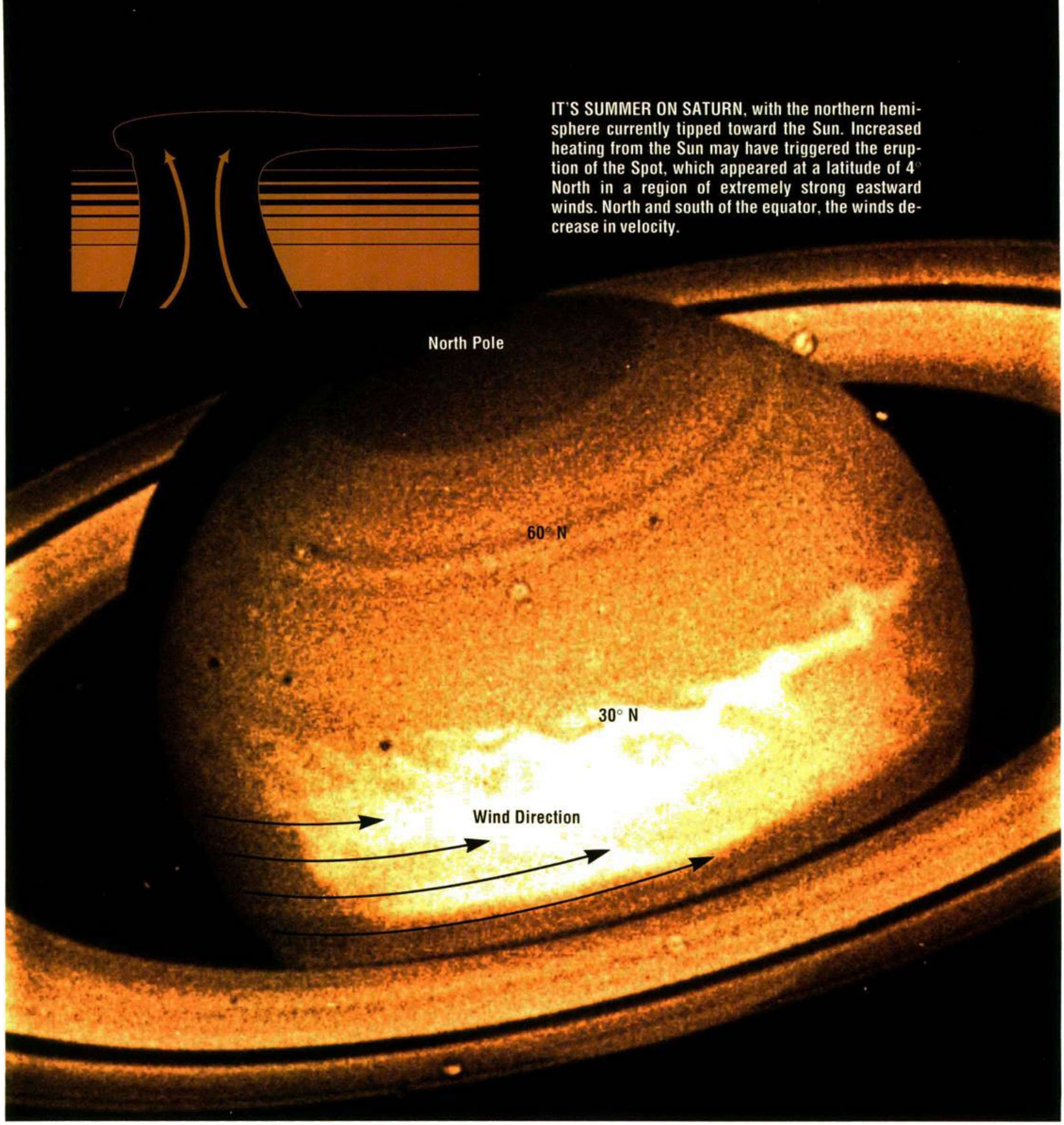
By early November, the collision between the fierce equatorial winds and the slow-moving mid-latitude winds at a latitude of about +30° sculpted the northern edge of the storm clouds into a series of waves and eddies. By this time, the view from Earth was of a Saturn with a bright featureless equatorial zone. It took the orbiting eyes of the *Hubble Space Telescope* to reveal the fine detail of the storm-tossed Saturnian clouds. In five weeks, the Spot had gone from a sight in Alberto Montalvo's driveway telescope to a target for the world's most sophisticated orbiting observatory.

A Summer Storm Cloud

The eruption of the Great White Spot wasn't totally unexpected. Similar massive outbreaks were seen in 1876, 1903, 1933, and 1960. Each occurred in the northern hemisphere during local midsummer on Saturn. Since Saturn takes 29.5 years to orbit the Sun, the seasonal connection explains the roughly 30-year time span between appearances of Great White Spots.

Because of the 26.7° tilt of its axis, Saturn experiences a seasonal heating and cooling similar to Earth — except that on Saturn each season lasts nearly seven years. On Earth the warmest days of northern summer don't occur at the June solstice but several weeks later in July and August. This is because it takes time for the increased heating from the Sun to warm the insulating atmosphere. So it is on Saturn.

In late 1990, Saturn's northern hemisphere was three years past summer solstice and the Sun had warmed the deeper layers of Saturn's cloud deck. And just as warm summer days cause towering thunder clouds to billow up on Earth, a similar heating of Saturn may have sparked a summer storm in *its* atmosphere. However, compared to



IT'S SUMMER ON SATURN, with the northern hemisphere currently tipped toward the Sun. Increased heating from the Sun may have triggered the eruption of the Spot, which appeared at a latitude of 4° North in a region of extremely strong eastward winds. North and south of the equator, the winds decrease in velocity.

THE SWIRLING EDDIES of Saturn's great storm of 1990 were captured on November 9 by the *Hubble Space Telescope.*

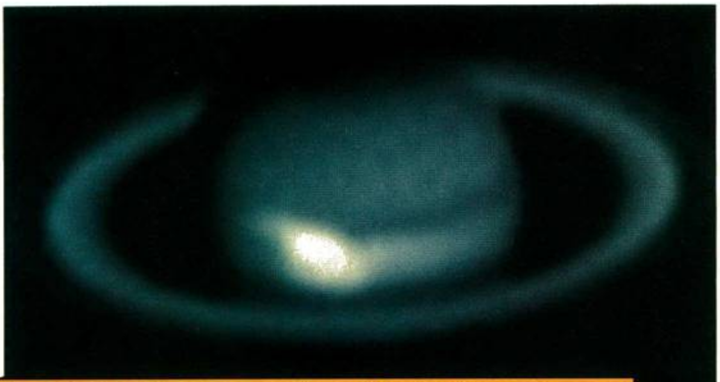
Earthly storms, the scale was vastly different. Saturn's storm began as a region roughly 15,000 miles across, wide enough to swallow the Earth, and lasted for several weeks.

However, planetary meteorologists are quick to point out that analogies with Earth are risky. For one thing Saturn, like Jupiter and Neptune, has an internal heat source that pumps warmth from below and fuels the weather systems on these giant gas planets. According to Chris Barnet, a Saturn atmosphere specialist working at NASA's Goddard Space Flight Center, "Even if you could turn off the sunlight to Saturn the planet would still have a source of energy to drive its weather systems," a process demonstrated at Neptune where solar heating is even lower than at Saturn.

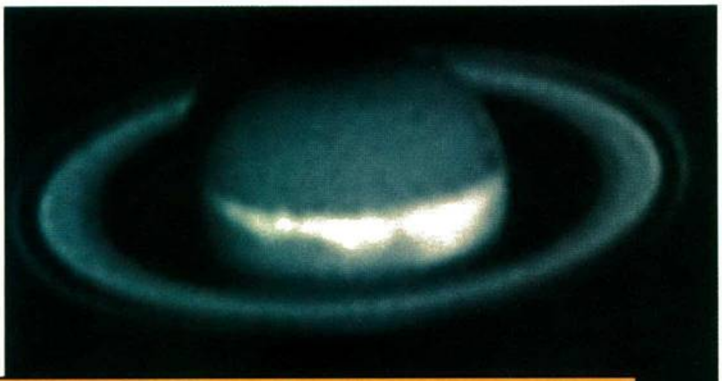
In addition, the seasonal connection is not as clear cut as it appears. Only the 1876, 1933, and 1990 Spots erupted at the equator and became major features. The 1903 and 1960 Spots were smaller and appeared at high northern latitudes. This suggests a sixty-year pattern of recurrence between major storms through a process that astronomers have yet to understand.

Sailing the Saturnian Winds

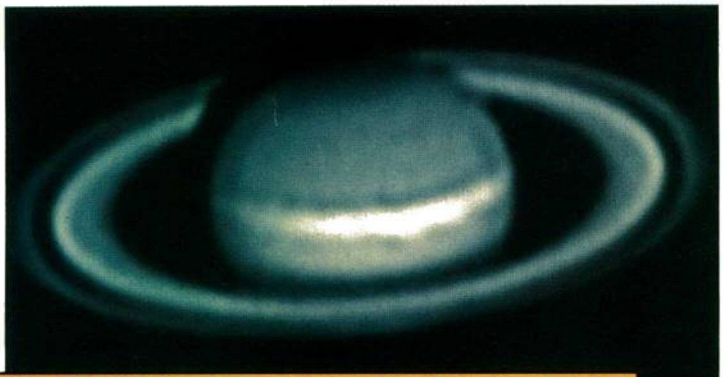
The White Spot was of interest by itself, but it also helped astronomers track the prevailing winds of Saturn. Because of Saturn's normally bland



OCTOBER 4: Early in its appearance, the oval Spot at the equator was prominent and well-confined in longitude. It first appeared at a latitude of +4°, but by early October, spot material had begun to migrate northwards.



OCTOBER 16: By mid-October, equatorial winds had stretched and distorted the Spot. The Spot lost its identity and appeared as a bright equatorial band. Icy ammonia crystals from the original eruption site had moved north to surround the planet.



OCTOBER 26: The Spot's ammonia ice clouds had spread around the planet, forming a bright band with little sign of the original Spot. Sequence of deconvolved CCD images taken in blue light with a 24-inch telescope. Images courtesy Reta Beebe, New Mexico State University.

appearance, it's usually difficult to see the effects of the winds. Then, as Reta Beebe, a planetary scientist at New Mexico State University, described it, "The Spot's bright material was inserted into the upper atmosphere, almost like a burst. It served as a visible marker that we didn't have during the *Voyager* era."

Ten years ago during the *Voyager* encounters, astronomers discovered Saturn's remarkable equatorial winds. The winds blow east at 1,000 miles-an-hour, some three-and-a-half times faster than Jupiter's turbulent clouds. In fact, Saturn's equatorial clouds whip around the planet faster than the planet rotates, taking 10 hours and 15 minutes to circle Saturn versus 10 hours and 39 minutes for the rotation of the interior of the planet. Astronomers still don't know why the winds are so strong or why they blow eastward. As Barnet commented, "We are still amazingly ignorant of what goes on on Saturn."

Andrew Ingersoll, a planetary scientist at NASA's Jet Propulsion Laboratory, added another mystery that Spot-trackers would like to solve: "As far as we can tell there is no good reason why Saturn's spots should dissipate or why Jupiter's spots should hold together." One obvious difference between Jupiter and Saturn is that Saturn's rings cast a wide shadow onto the tops of the clouds. Right now, much of Saturn's southern hemisphere is being shadowed by the rings during part of each day. Does this affect the Saturnian weather? Barnet has made a point of studying just this question, and his answer is surprising. "The rings have no effect," he explained. "Saturn's atmosphere is mostly hydrogen and helium and these gases are good at retaining heat and are cold enough that the shadowed atmosphere does not radiate heat well. In addition, the strong winds damp out any minor temperature fluctuations that do arise from the ring shadow."

Another question scientists hope to answer is how deep the White Spot material came from. As Ingersoll pointed out, "The material could be from high in the atmosphere, but the upper atmosphere shouldn't be able to store as much energy as we saw released in the eruption of the Spot. On the other hand, the correlation with the seasons suggests the source of the material can't be lower than the level to which sunlight penetrates."

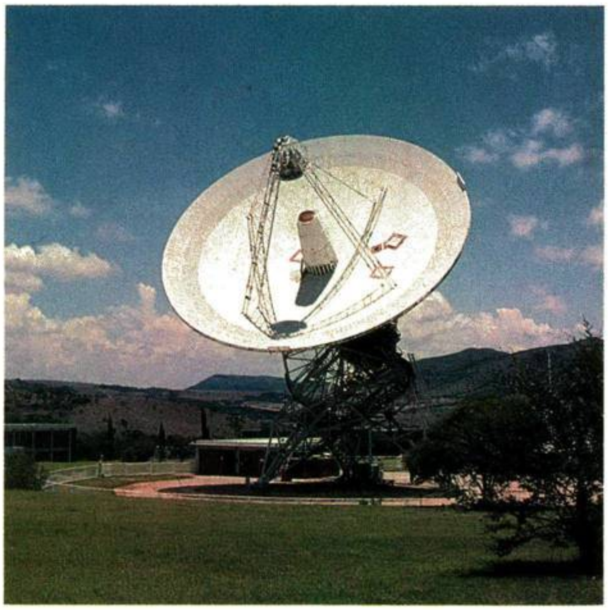
Unfortunately, the White Spot burst forth shortly before Saturn disappeared behind the Sun, curtailing observations of the Spot's evolution. However, when Saturn reappears in 1991, the *Hubble Space Telescope* will likely be turned again to track Saturn's clouds. In the meantime, astronomers are busy enhancing nearly 300 Saturn images taken by the *HST* in mid-November. These will be assembled into a time-lapse movie. By analyzing the wind-driven motions of the clouds, scientists may be able to solve some of the problems posed by Saturn's mystery spot.

And, of course, as soon as Saturn reappears in the dawn sky, Alberto Montalvo will be there in his backyard, patiently watching. Says Montalvo, "I'll be looking at Saturn now more than ever. I may not live to see the next great spot but, who knows, perhaps the planet will surprise us." □

The Southern Radio Sky Comes to Light

A startling view of the southern Milky Way resulted when a group of astronomers converted an old NASA tracking antenna into a radio telescope.

by Gerrit L. Verschuur

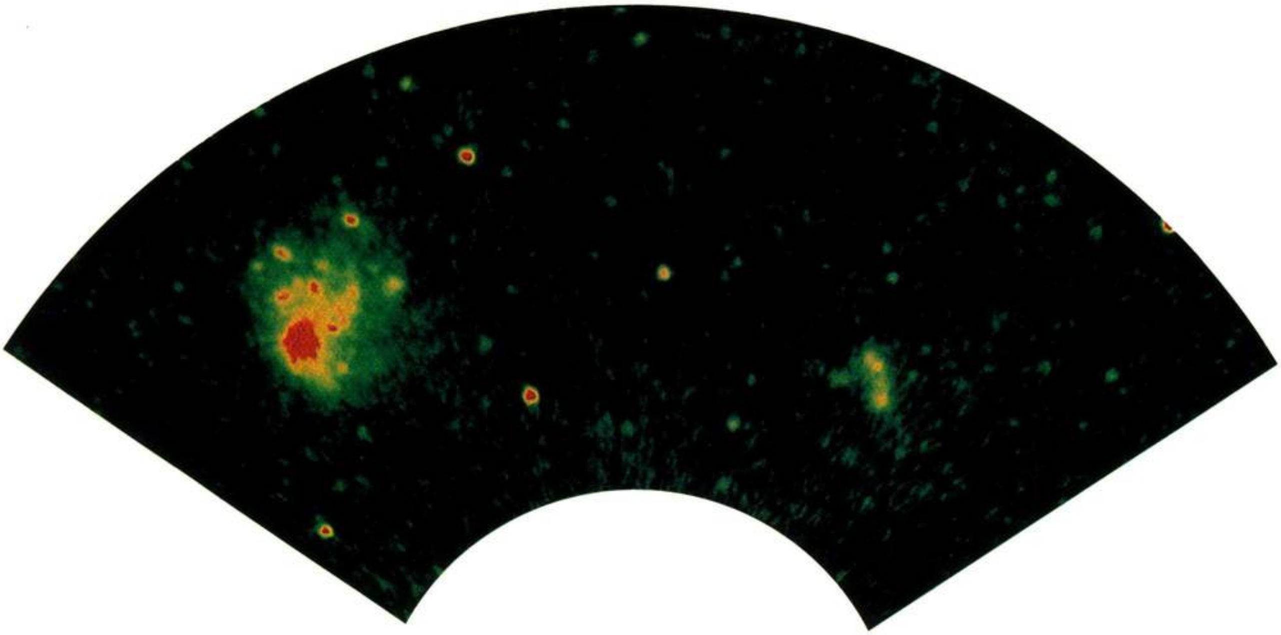


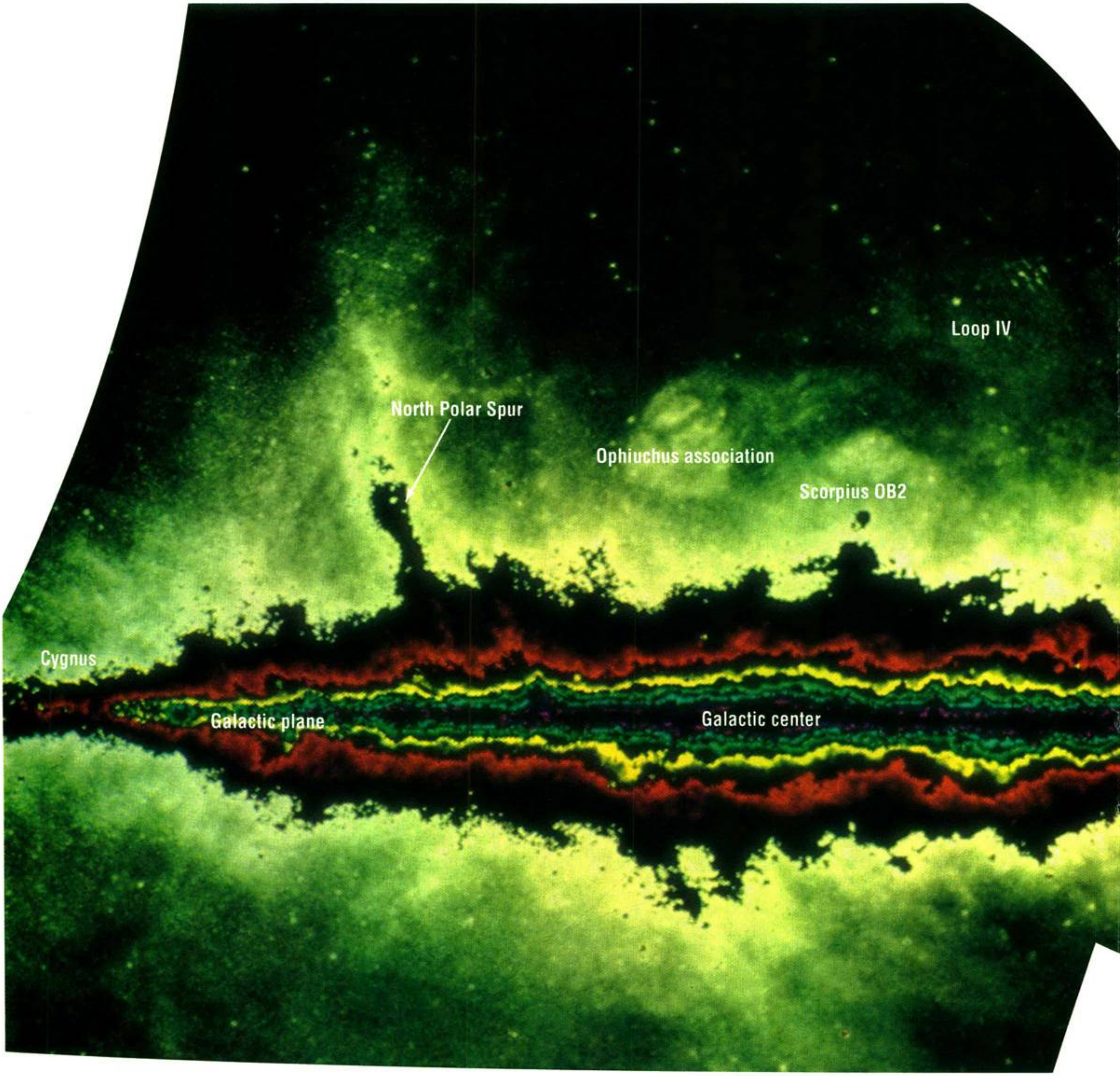
"They took everything not bolted to the floor," said grad student Justin Jonas. "But they *had* to leave the dish."

When NASA abandoned its satellite tracking dish in Hartebeesthoek, South Africa, in the early 1970s, the 26-meter antenna posed both an opportunity and a challenge to the group of astronomers connected with Rhodes University in Grahamstown who inherited the installation. Together with astronomers Eddie Baart and Gerhard de Jager, Jonas and several others outfitted the antenna with sensitive receivers and began to survey the southern radio sky, which was virtually unobserved, especially at short wavelengths.

The photo on pages 40 and 41 shows a false-color view of the Milky Way from the survey, made at 2300 MHz (about 13 cm wavelength). The image extends

ONCE IT TRACKED SATELLITES around Earth, now it probes deep into our Galaxy: this recycled NASA antenna has a new job in the hands of South African astronomers. Below: the Large and Small Magellanic Clouds.





JETS, STREAMERS, AND BUBBLES throng the radio Milky Way just as they do the visible. The Galactic plane forms the thick band across the picture, while supernova remnants and clouds of gas appear projected above it.

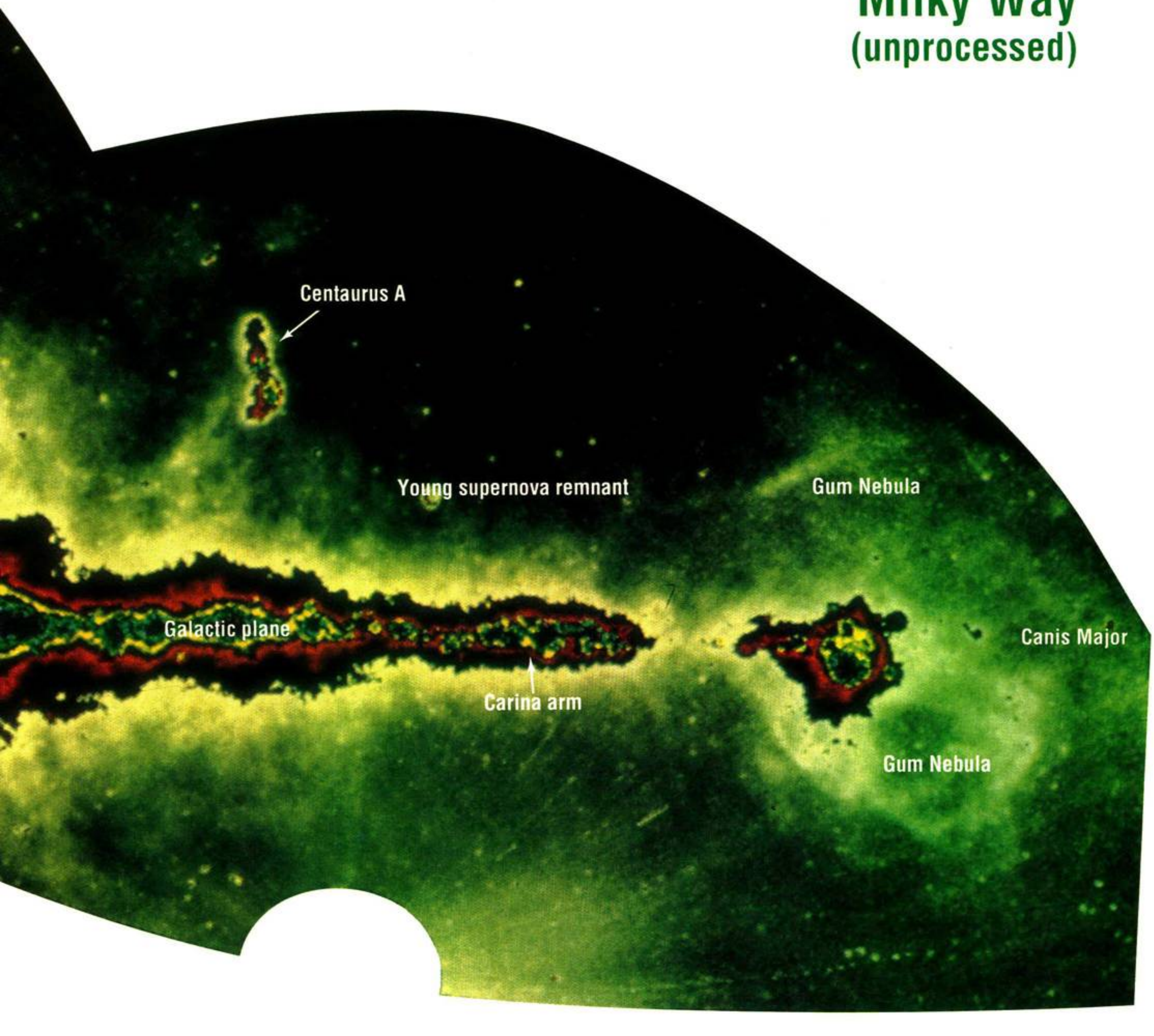
from Cygnus (Galactic longitude 70°) on the left through the Galactic center in Sagittarius (0°) to Canis Major (240°) on the right. Vertically, it spans from Galactic latitude 30° south to 60° north.

The radio emission of the Milky Way comes from cosmic ray electrons spiraling around in magnetic fields at nearly the speed of light as they thread a path between the stars. The wide band roughly matches the Milky Way we see with the naked eye. But while the visible Milky Way is produced by stars lying within a couple thousand light-years of the Sun, the radio waves originate 10,000 to 50,000 light-years away.

A great deal of structure shows in the radio survey: filaments (both large and small), knots, and loops. Almost all belong to our Galaxy. One object, however, does not: the small double feature Centaurus A is associated with the enigmatic galaxy NGC 5128, which lies about 15 million light-years away — deep in space beyond the Galaxy's farthest frontier.

This double radio source results from hugely energetic events in the core of NGC 5128. Repeated explosions have hurled twin jets of radio-emitting gas to

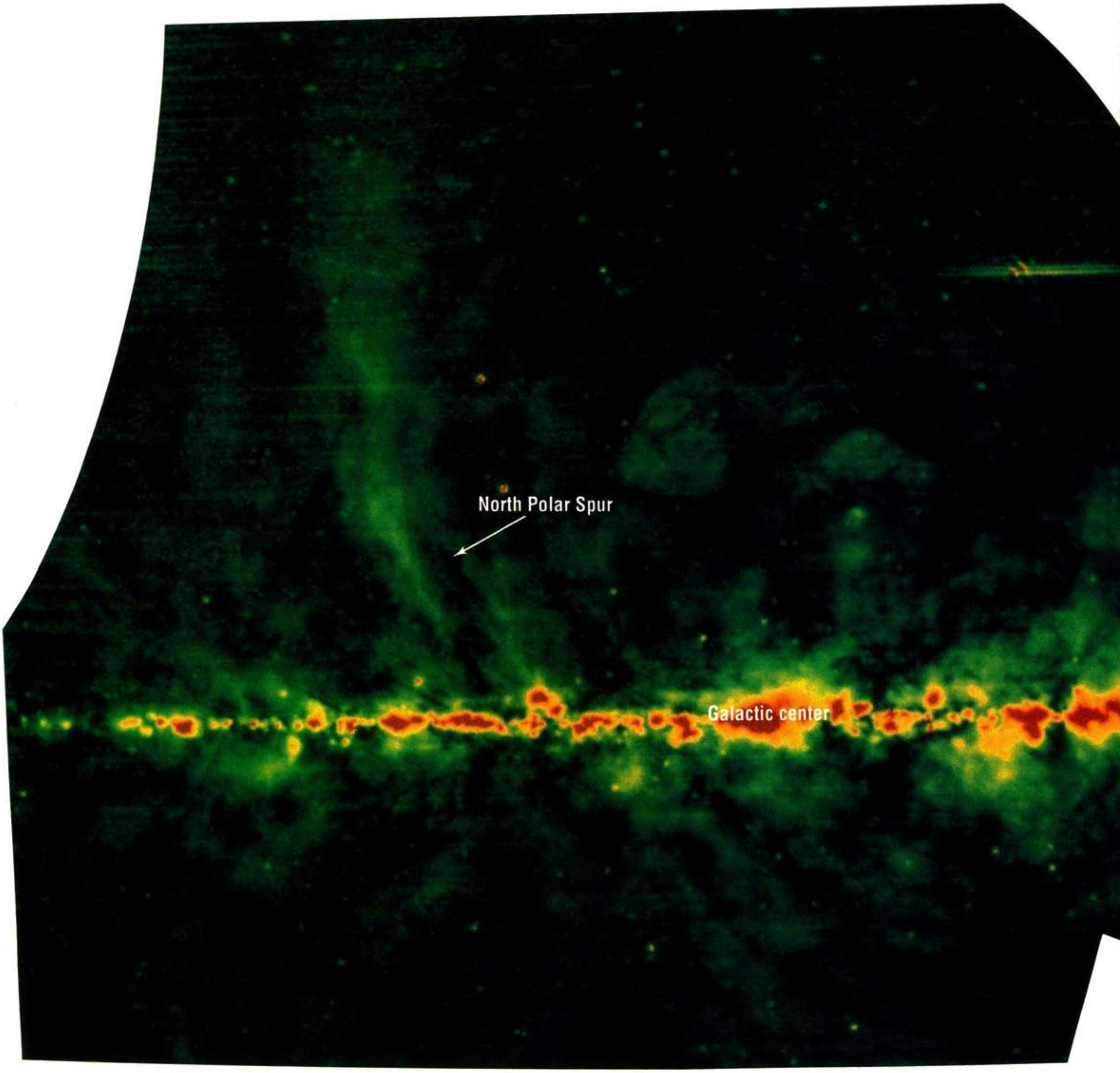
The Southern Radio Milky Way (unprocessed)



distances of 500,000 light-years. Centaurus A now extends over a distance more than three times the diameter of our own Galaxy. (Astronomers think, however, that the apparent thread linking Centaurus A to the Milky Way is a chance alignment of a nearby feature with the distant galaxy.)

In the Milky Way image a large streamer of emission called the North Polar Spur rises out of the band. Many astronomers believe this is a fragment of energized gas some 330 light-years distant left over from a supernova explosion that occurred about a million years ago. It aligns with the local magnetic field of the Galaxy (see "The Magnetic Milky Way," ASTRONOMY, June 1990).

To the right of the North Polar Spur is a circular structure surrounding a group of hot stars in Ophiuchus, while to its right and a little lower is a loop structure belonging to the Scorpius OB2 stellar association. These features are produced by hot gas surrounding relatively nearby stars. In the center of the image stands a faint and broad ridge of emission called Loop IV, which may be the remnants of another old supernova. Toward the right end of the Milky Way, the Carina spiral arm glows brightly because we are looking down its axis. The small, bright object above and slightly to the left of Carina is a young supernova remnant perhaps a few tens of thousands of years old.



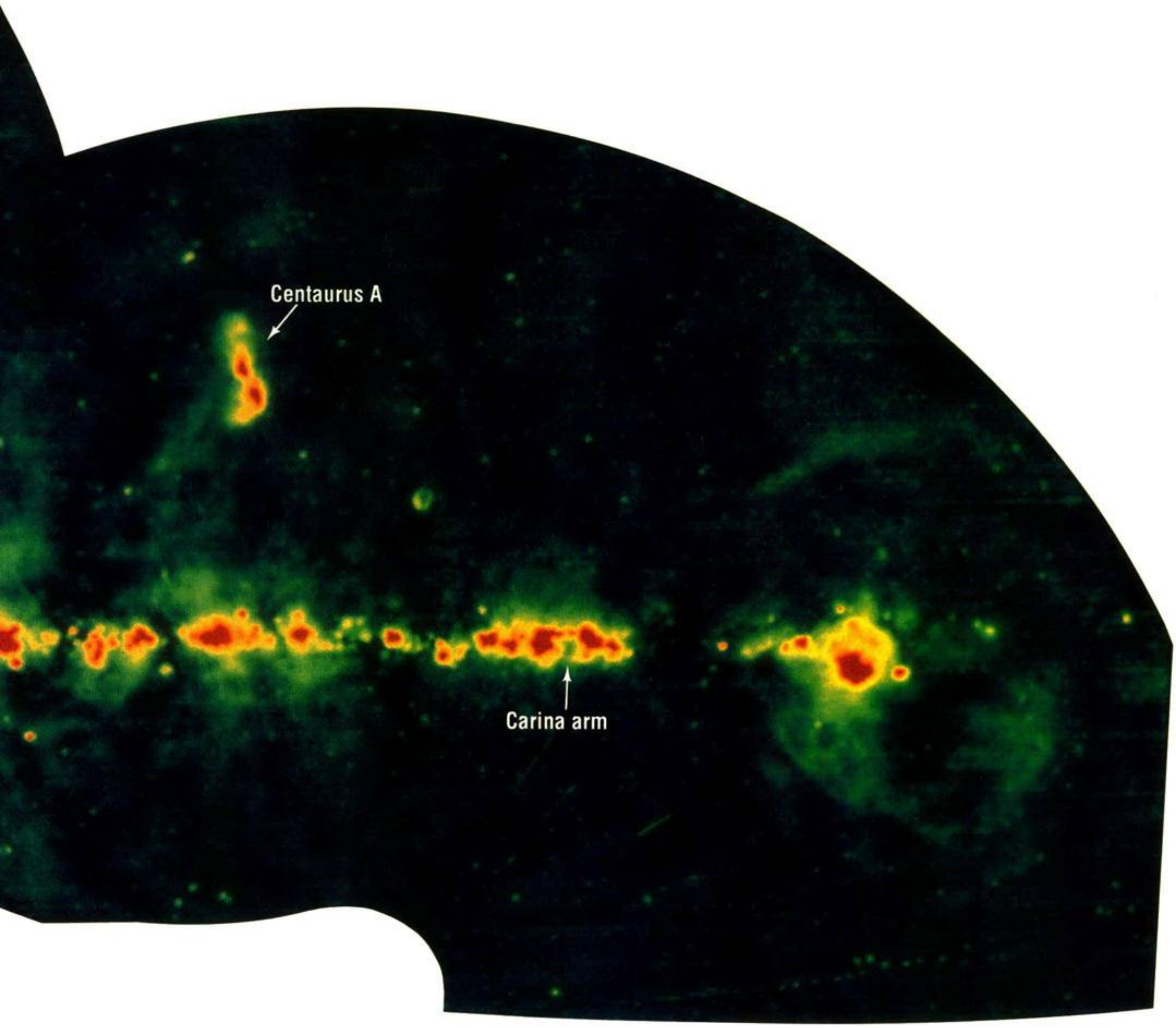
SUBTRACTING AN IDEALIZED GALAXY contour from the image revealed details in the Galactic plane. Note that many of the streamers extending above and below the Galaxy appear to be rooted in knots that lie in the central plane.

The "island" of emission at the right end is the Vela supernova remnant, famed for its pulsar, one of the few visible optically. The Vela SNR lies inside a region of swirling filaments called the Gum Nebula, which surrounds it both above and below the Milky Way. The Gum Nebula (named for its discoverer, Colin Gum) is a big cloud of hot gas heated by young stars, one of which exploded as the Vela supernova.

The image on pages 40-41 conceals most of the underlying structures of the Milky Way. To make them clearer, astronomers subtracted the profile of an idealized galaxy from the observed emission. The result is on these pages. Note how many of the knots in the plane appear to correlate with features extending above and below. Astronomers are now working to understand why these ridges, filaments, and loops occur where they do. When the survey is complete — it has been underway for more than 11 years — the Rhodes University astronomers plan to repeat their observations at 6 cm wavelength. This new look at shorter wavelengths will reveal finer details.

Over the last decade Rhodes University astrono-

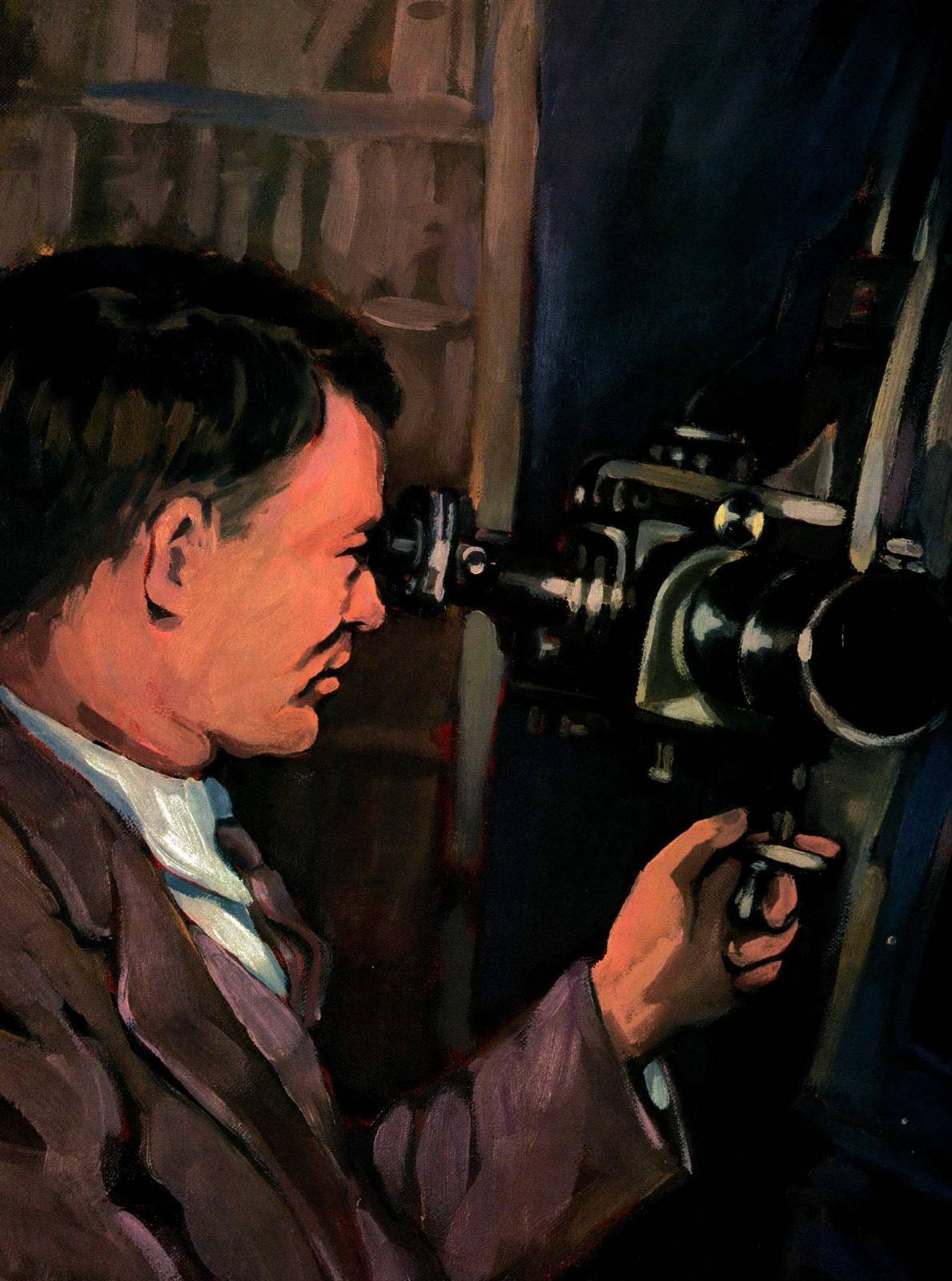
The Southern Radio Milky Way
(detail enhanced)



mers have steadily nursed sections of their huge database of observations through the computers with the aid of graduate students including Mike Wright, Justin Jonas, and currently Beate Woermann. The telescope's resolution of 20 minutes of arc means that vast numbers of observations are required to complete such a survey. The difficulty is compounded because most observations must be repeated to eliminate "noise" from manmade interference: significant — and growing — amounts of data are being lost due to satellite transmissions, which swamp the natural signals the way light from an errant flashlight can ruin an astrophoto.

Very few radio scopes have probed the southern Milky Way and the great expanses around the south celestial pole, where the Magellanic Clouds reign supreme. When an out-of-work radio dish met a team of determined astronomers, the result was a premier scientific instrument for exploring these skies. It is also an example that other nations, unable to afford building their own large radio telescope dishes, may hopefully follow. ☐

Gerrit L. Verschuur is a freelance science writer and researcher in Bowie, Maryland. He is the author of Interstellar Matters *(Springer-Verlag) and "The Magnetic Milky Way" in the June 1990 issue.*

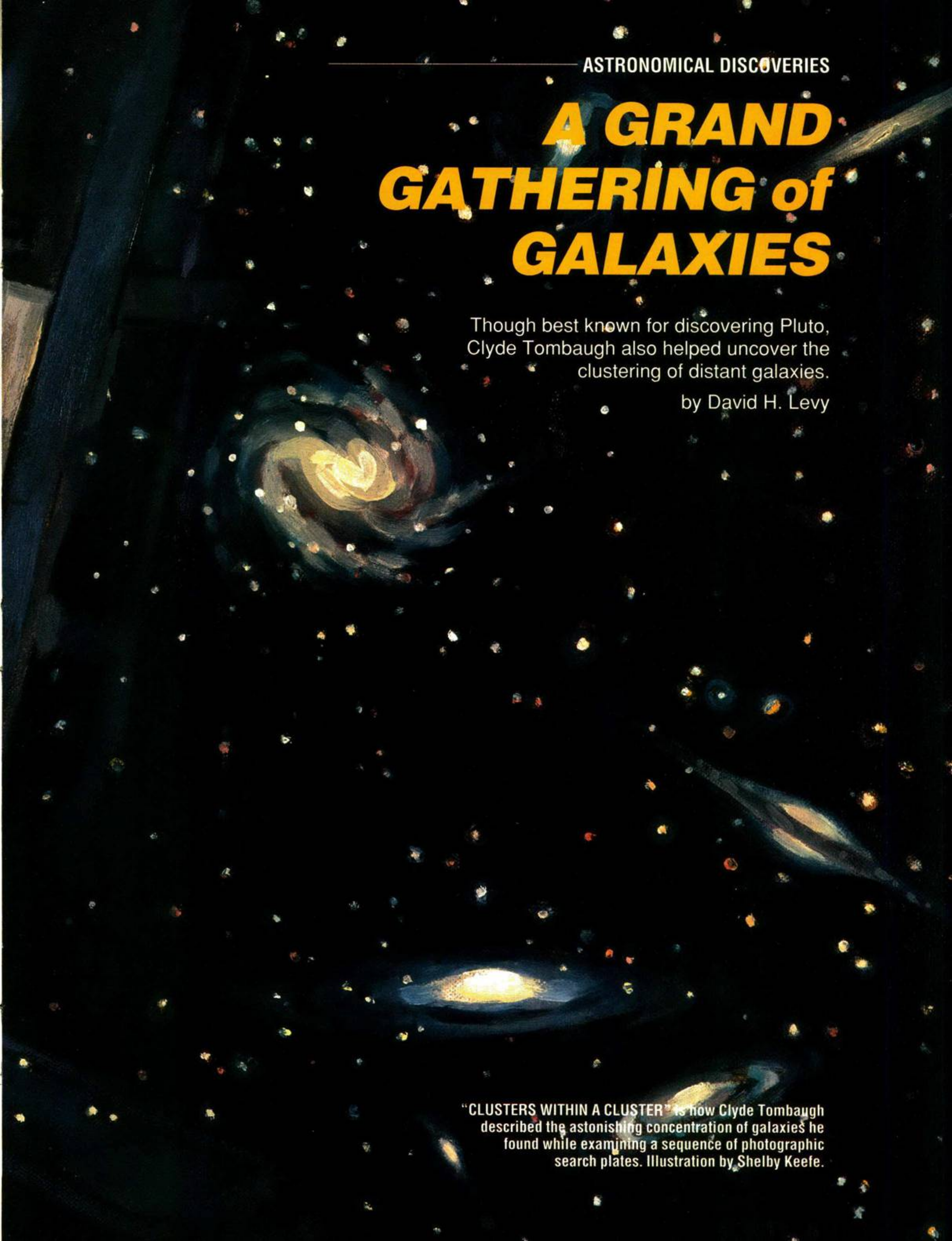


ASTRONOMICAL DISCOVERIES

A GRAND GATHERING of GALAXIES

Though best known for discovering Pluto, Clyde Tombaugh also helped uncover the clustering of distant galaxies.

by David H. Levy



"CLUSTERS WITHIN A CLUSTER" is how Clyde Tombaugh described the astonishing concentration of galaxies he found while examining a sequence of photographic search plates. Illustration by Shelby Keefe.

Just over one year after he arrived at Lowell Observatory in Flagstaff, Arizona, Clyde Tombaugh had his planet. He discovered Pluto on the afternoon of February 18, 1930, while he was scrutinizing a pair of photographic plates he had made less than a month before. Discovering Pluto was a triumph for Tombaugh. But Pluto was only one of many interesting objects he had found on the plates.

During the next fourteen years, Tombaugh would find thousands more as he carefully searched through over three hundred pairs of photographic plates. Nowhere did this effort pay a bigger dividend than in his counts of galaxies. By studying the distribution of galaxies on the plates, he independently discovered the first known supercluster of galaxies — a cluster of galaxy clusters. The discovery not only heralded a new era in the study of the structure of the universe, but also put him squarely at odds with one of the pre-eminent astronomers of the day, Edwin Hubble.

Tombaugh was able to make this discovery because of his exhaustive examination of the hundreds of photographic plates. Shortly after his search for a planet beyond Neptune commenced in 1929, he had begun to count and keep lists of the number of galaxies he found on the plates, as well as the number of variable stars, asteroids, and comets. He continued to keep the lists throughout the fourteen years of the trans-Neptunian planet search.

This was grueling work. He spotted all these objects while sitting at the blink comparator — a machine that allowed him to compare two photographic plates of the same area of sky taken several days apart. As the machine switched his view rapidly back and forth between the two plates, he would notice any object that changed position or brightness. The blink comparator was perfect for revealing the tiny orbital motion of Pluto, but it required great concentration to use effectively. Fortunately, compiling the lists of interesting objects entailed little additional effort.

Tombaugh remarks, "My thought was to get everything out of this tedious blinking that I could. If I were going to all this trouble, bleed it to death! That was my attitude." This is why Tombaugh began to keep his *lists* of interesting objects. And this is why he was able to recognize the supercluster.

The Nature of Galaxies

A century and a half before Tombaugh, another planet discoverer — William Herschel — began to wonder about the strange nebulae he was seeing in his telescope. These curious fuzzy patches, which were scattered over much of the sky, puzzled astronomers. In 1775 the philosopher Immanuel Kant proposed that nebulae were "island universes," each equivalent in size and complexity to the Milky Way.

Although Herschel accepted the island universe idea at first, by 1791 he was changing his view. At least some nebulae had starlike central condensations, and he reasoned that if we could see stars in other universes, they must be inordinately large. But another aspect of the nebulae was bothering him. How could nebulae be independent of the Milky Way system if their distribution seemed to be wholly related to it? Nebulae that could be resolved into stars abounded in the Milky Way, yet nebulae that could not be resolved tended to congregate away from it. It was obvious to Herschel that if nebulae were really separate universes, their distribution would not be so intertwined with our own system.

Our understanding of the huge systems of stars we now call galaxies took a leap forward early this century at Lowell Observatory. In 1912, acting on a suggestion by Percival Lowell, who suspected that the fuzzy, nonstellar objects called "spiral nebulae" might be new solar systems being formed, Vesto M. Slipher took a spectrum of the Andromeda Nebula (M31). This was the first of over forty spectra — at exposures of up to forty hours each! — Slipher took of different nebulae. Most of these spectra had absorption lines that showed anomalous shifts toward the red, a discovery that later showed the nebulae were moving away from us.

Slipher's find probably did more than anything else in a century to push ahead our understanding of nebulae. But it was not until 1924 that the true nature of the nebulae became apparent. That was when Edwin Hubble, observing with the 100-inch reflector on Mt. Wilson in California, measured the distances to many galaxies through his study of the galaxies' Cepheid variable stars. Hubble's role was crucial in establishing that the spiral nebulae were actually very distant aggregates of stars. As the distant nature of these objects became better understood, Harlow Shapley of Mt. Wilson Observatory suggested that they should be called galaxies instead to avoid confusing them with the gas clouds in the Milky Way that go by the same name.

The Clustering of Galaxies

The number of known galaxies grew rapidly in the 1930s and 1940s, due in no small part to the continuing planet search at Lowell Observatory. Soon after Tombaugh discovered Pluto, astronomers calculated that the ninth planet was much smaller than predictions had led them to expect. Was there another, much larger planet beyond the orbit of Neptune? Or might Pluto be the tip of an iceberg, with similar objects just waiting to be found in the outer reaches of the solar system? To answer those questions, the observatory had decided to continue the trans-Neptunian planet search.

After graduating from the University of Kansas in the spring of 1936, Tombaugh returned to Lowell full-time. From August 12 of that year until the middle of 1943, with the exception of the 1938-39 academic year when he earned his Master's degree, he continued blinking plates uninterrupted.

By keeping careful notes about the number of galaxies he found on each of his plates, Tombaugh was conducting a survey of all the galaxies brighter than about 16th magnitude visible from Lowell Observatory. Although it was not the first survey, its importance has been greatly understated. Early surveys by Charles Messier (about 110 objects), William Herschel, and John Dreyer (his *New General Catalogue* contains over 7,000 objects) had vastly increased our understanding of the distribution of nonstellar objects, but those surveys were more thorough in some regions of the sky than in others.

Possibly the first all-sky survey intended especially for galaxy studies was prepared by Harlow Shapley and Adelaide Ames from Harvard College Observatory patrol plates. Conducted from 1930 to 1932, the survey revealed 1,249 galaxies down to a magnitude of about 13. Although this is not a large number of galaxies, the survey was important because the plates had been exposed uniformly across the entire sky.

In contrast to the earlier surveys, Tombaugh's trans-Neptunian planet survey produced a total of 29,548

galaxies! Although subsequent surveys have included more galaxies, at the time it was the biggest galaxy survey of all.

Upon his return to Lowell in 1936, Tombaugh was assigned both to take the search plates and to blink them afterward. Because he could expose a plate in about an hour but needed a week or so to blink the plate, the blinking quickly fell far behind the photography. Observatory trustee Roger Lowell Putnam and director Vesto Slipher soon secured two small grants from the American Philosophical Society's Penrose Fund so the search could proceed faster. Henry Giclas then took over photographing the sky so that Tombaugh could spend his time blinking the plates.

The search had by then covered all the sky near the zodiac, so Tombaugh and Giclas moved into regions quite far from the zodiac. In the autumn of 1936, Giclas photographed a series of regions in the constellations of Pegasus, Andromeda, and Perseus. Tombaugh soon noticed a sudden change — a major increase — in the numbers of galaxies he was counting in a plate of the northern half of the Great Square of Pegasus. The density of galaxies had risen to about six per square degree, about twice the typical rate for similar areas away from the Galactic plane. Because it took him a week to nine days to blink through a single pair of plates in these regions, Tombaugh did not realize for several months the extent of what he had found.

What his counts of non-planetary objects had revealed was a vast cloud of galaxies beginning suddenly in the Square, then passing behind Alpha Andromedae, proceeding eastward along an arc south of Beta and Gamma Andromedae (including northern Triangulum), contracting in Perseus as its northern part met the Milky Way, and coming to a point and stopping just east of Beta Persei. The area covered by the cluster was so large that at first Tombaugh was not aware that what he had seen was terribly unusual; he may have gone through an entire pair of plates before noticing that this was more than just a chance increase in the number of galaxies.

Through plate after plate the clustering progressed. "I was really beginning to get flabbergasted about it," said Tombaugh. "I'd mark on the plates where the density would seem to fall off and then plotted on an atlas the shape and extent." The edge of the group in Perseus was so pointed and obvious that it removed any doubt in Tombaugh's mind that it represented an organized system.

The brightest of the galaxies were of 14th magnitude, and he detected galaxies down almost to the telescope's limit of about 17th magnitude. Not only was the sheer size of this system unusual, but so was its shape, like that of a banana. The pointed eastern edge could be explained partly by interference from the Milky Way, but there seemed to be no ready explanation for the sharpness of the boundary elsewhere.

Unlike the other discoveries made during the planet search, this one occurred gradually, so Slipher was not surprised when Tombaugh spoke to him about the cluster's extent. "I think we have a very interesting concentration of galaxies here that has exceeded anything I've run into," Tombaugh concluded. Although this was not the only cluster of galaxies he discovered during the search, it was the largest.

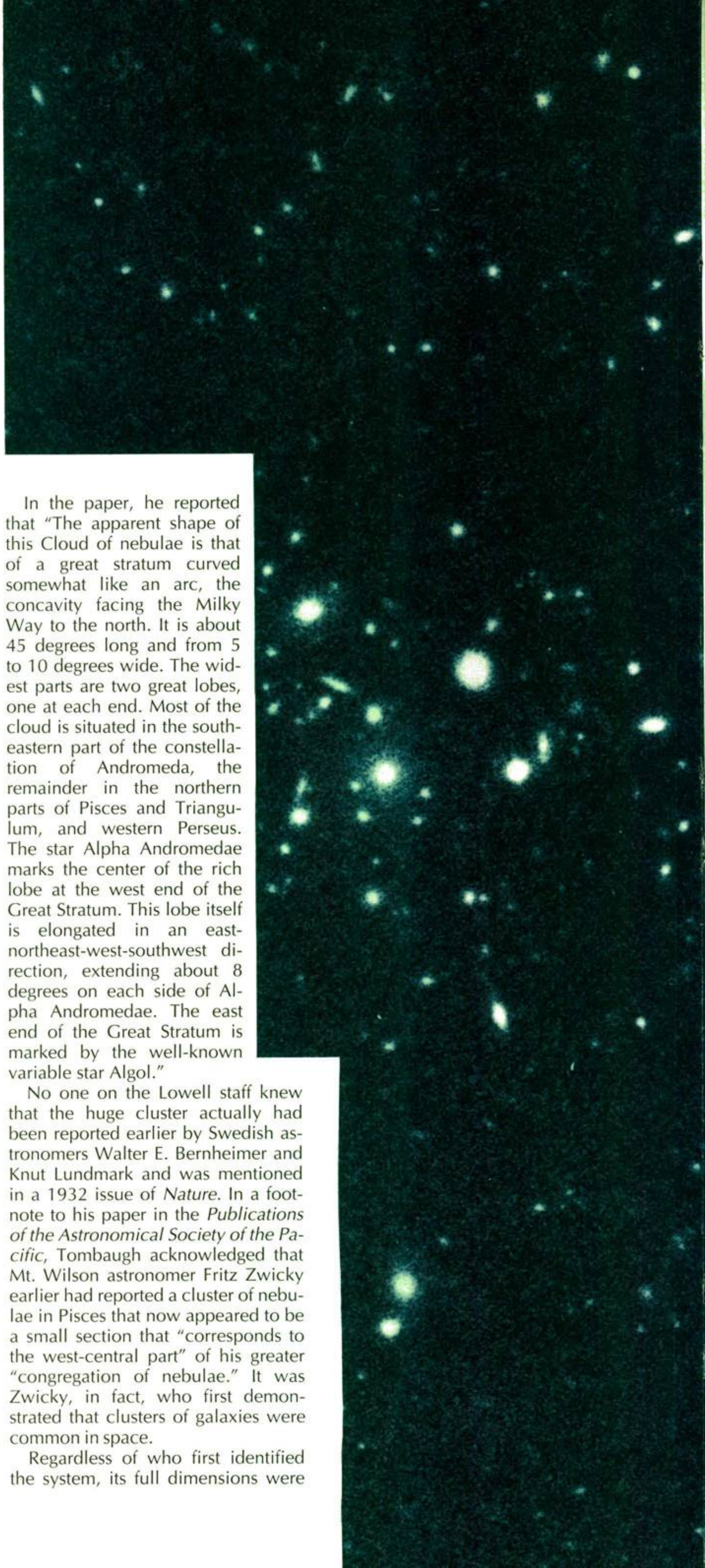
He called this huge cluster the "Great Perseus-Andromeda Stratum of Extra-Galactic Nebulae." Slipher was delighted with Tombaugh's find, and was anxious that he publish it. Tombaugh today suggests that the director was "particularly proud that the Lowell Observatory had found that." Publishing the paper in the *Publications of the Astronomical Society of the Pacific* was Tombaugh's idea; at the time it was one of the most widely read astronomical publications.

Accordingly, Tombaugh prepared a paper for the June 1937 meeting of the Astronomical Society of the Pacific in Denver, and for later publication in the *Publications of the Astronomical Society of the Pacific.* The paper showed the cluster's enormous extent — in all, Tombaugh counted 1,800 galaxies in this area.

In the paper, he reported that "The apparent shape of this Cloud of nebulae is that of a great stratum curved somewhat like an arc, the concavity facing the Milky Way to the north. It is about 45 degrees long and from 5 to 10 degrees wide. The widest parts are two great lobes, one at each end. Most of the cloud is situated in the southeastern part of the constellation of Andromeda, the remainder in the northern parts of Pisces and Triangulum, and western Perseus. The star Alpha Andromedae marks the center of the rich lobe at the west end of the Great Stratum. This lobe itself is elongated in an east-northeast-west-southwest direction, extending about 8 degrees on each side of Alpha Andromedae. The east end of the Great Stratum is marked by the well-known variable star Algol."

No one on the Lowell staff knew that the huge cluster actually had been reported earlier by Swedish astronomers Walter E. Bernheimer and Knut Lundmark and was mentioned in a 1932 issue of *Nature*. In a footnote to his paper in the *Publications of the Astronomical Society of the Pacific,* Tombaugh acknowledged that Mt. Wilson astronomer Fritz Zwicky earlier had reported a cluster of nebulae in Pisces that now appeared to be a small section that "corresponds to the west-central part" of his greater "congregation of nebulae." It was Zwicky, in fact, who first demonstrated that clusters of galaxies were common in space.

Regardless of who first identified the system, its full dimensions were



first revealed on Tombaugh's 13-inch-telescope plates. "I found clusters within a cluster, within the cluster. It was the richest region of galaxies I had ever encountered."

The Extent of Clustering

Far-sighted and imaginative, Edwin Hubble had also been making a survey of the arrangement of the galaxies in space. His survey, made with the 100-inch reflector on Mt. Wilson, avoided both obvious clusters of galaxies and the Milky Way (an area he called the "zone of avoidance" because dust in our galaxy blocks our view of the regions beyond).

Although the 100-inch telescope could penetrate to a very faint magnitude, it could not cover the entire sky. To bypass this difficulty, Hubble took plates at specific and evenly distributed regions of sky. The farther he moved away from the Milky Way, the more galaxies he found. The result of his survey showed an isotropic, or even, distribution; counts from his specific plate regions clearly showed that galaxies are distributed evenly. From this he derived the "cosmological principle," which states that the uniformity we see portrays the real structure of the universe.

Hubble was aware that on relatively small scales, for instance in the constellations of Coma Berenices and Virgo, the distribution of galaxies is conspicuously nonuniform. Galaxies sometimes congregate in groups that can have just a few members up to a thousand members or more. To avoid having these areas bias his results, he avoided them in his survey. His point was that, when averaged over the total volume of the universe, the distribution was even. Hubble also suggested that all galaxies may be clustered, but that the clusters are evenly spread. Large as the Coma-Virgo system appears from Earth, on the scale of the entire universe it is one of thousands of clusters of similar size.

Hubble thought that his cosmological principle applied at a level above that of the clusters of galaxies. Tombaugh disagreed. With discoveries like his huge stratum, with its sublayers of clustering, he felt that the distribution might be nonuniform at this higher level. It was the scale of uniformity at the cluster level that caused Tombaugh to disagree with Hubble.

Meeting with Hubble

Although Tombaugh first met Edwin Hubble in 1940, the two met several times during the 1945-46 academic year. At that time, Tombaugh was teaching a course at UCLA and could visit Hubble by driving to his Pasadena office. From Tombaugh's viewpoint, the two men saw things from two totally different directions. By then Tombaugh had examined about 70 percent of the entire sky to a resolution of 4 arcseconds and a magnitude limit of about 17. "I knew that the distribution of galaxies was extremely patchy, but I couldn't convince him." With the mighty 100-inch telescope Hubble had seen much smaller areas, but to a far dimmer magnitude limit than Tombaugh could achieve with a 13-inch camera. Tombaugh's visits grew out of a concern he felt from reading Hubble's book, the *Realm of the Nebulae.* He recollects one of their 1946 conversations:

"I began by saying, 'Dr. Hubble, on my plates, I have made counts. I have seen the area, and I don't agree with the conclusion you have drawn in the distribution. I find marked irregularities. I see the voids and the concentrations, even at high galactic latitudes. What I have seen on my plates does not agree with what you have said.' He seemed a bit shocked about it. But I couldn't convince him."

Tombaugh's wife Patsy concurs: "Hubble was very courteous, but he just didn't react to it; he just discounted what Clyde was saying. He didn't even argue very much about it."

Hubble remarked merely that the plates he had seen, taken in small areas but over selected regions spread out over the sky, showed a fairly uniform distribution. Tombaugh then offered to show him his records, in which he had kept careful count of the number of galaxies on each plate. Hubble was apparently not interested in seeing those either. It would have involved a lot of looking on Hubble's part — Tombaugh had counted 29,548 galaxies. Hubble probably didn't realize how much material Tombaugh had assembled. Never before had such a detailed survey of the sky been taken, and another one would not begin for some years. Tombaugh's lack of a doctorate was likely another reason why his arguments were not taken more xseriously by Hubble.

In 1937, the year of Tombaugh's paper in the *Publications of the Astronomical Society of the Pacific,* Erik Holmberg and Anders Reiz independently demonstrated that the Local Group, which includes our galaxy, is part of a much larger swarm of galaxies. Two decades later Gerard de Vaucouleurs began a much more intense study that revealed the existence of the Local Supercluster that includes the Local Group and the Coma Berenices and Virgo clusters. Considering Tombaugh's experiences, it may not be too surprising that many astronomers, apparently including Hubble, ignored these two

important pieces of work.

In the second half of the 1940s, astronomers at Lick Observatory and at Palomar Mountain in California made photographic surveys of the entire sky. The Palomar Survey produced the most extensive sky atlas ever made. George O. Abell, a central figure in the Palomar survey, catalogued 2,712 clusters of galaxies from the data. In 1958, Abell published his results in a huge Ph.D. thesis that demonstrated that several thousand large clusters visible at very large distances are not randomly distributed in space, but instead tend to associate in huge "great clusters," or superclusters.

This is exactly the point Tombaugh had been trying to make to Hubble thirteen years earlier. Abell concluded from his and other studies that the matter in the universe seems to be gathered into superclusters that average three hundred million light-years across. Although Hubble's cosmological principle of uniform distribution may be maintained at the supercluster level, on a smaller scale

there are voids and concentrations of clusters into superclusters that the Tombaugh plates showed so well. In addition to the supercluster Tombaugh recorded (now known as the Pisces-Perseus supercluster) and the Local Supercluster that includes the Local Group and the Virgo cluster, other superclusters were eventually found centered in the constellations of Fornax, Hydra, and Pavo.

On scales larger than the superclusters, does the universe continue to be hierarchical? Are there megaclusters, or clusters of superclusters, and clusters of megaclusters? The answer is important, because if there are, the average concentration of matter in the universe would be much less than what it would be if the cosmological principle holds. In fact, if the hierarchy goes on infinitely, then the average density approaches zero! Abell predicted that there is no hierarchy beyond that of the supercluster.

The Search Ends

For all Tombaugh's work, his contribution is not remembered in the literature because, aside from the one article about the Perseus-Andromeda stratum, he never got the chance to publish his ideas. During World War II, Tombaugh became involved in teaching navigation and other war-related activities. In the spring of 1944, Frederick Leonard, a highly regarded teacher of astronomy at UCLA, invited Tombaugh to teach for two semesters. A specialist in meteorites, Leonard had known Tombaugh since the early 1930s. While at UCLA, Tombaugh taught beginning astronomy and the history of astronomy. It was a very different experience from the quiet at Lowell. Between teaching and grading papers, he had little free time.

When Tombaugh returned to Lowell from Los Angeles, Slipher told Tombaugh that the observatory's finances were very tight and that he "should find other employment." Tombaugh was so shocked and hurt by the news that he doesn't recall the exact conversation. He does remember Slipher's pointing out his teaching experience and saying that his real calling lay in education. "He was so hurt he didn't even tell me," Patsy notes, adding that it was many months before she learned of the nature of that conversation.

Part of the reason for letting Tombaugh go was obviously financial. Also, with the planet search winding down, the observatory may have felt that Tombaugh simply was no longer needed. As soon as Slipher suggested he leave, Tombaugh lost all interest in doing anything more with the plates. The hurt feelings ran so deep that he did not bother debating Slipher about the importance of continuing with the studies of galaxy distribution and other byproducts of his planet search. It was never Tombaugh's nature to insist on continuing when he felt that he wasn't wanted, even in the unlikely event he had the means to do so independently.

"I felt I had earned a status of some import and they weren't going to give it to me," says Tombaugh. "I felt terribly upset to know that all those data on nebulae were down the drain.... I could have made a real name for myself in the galaxy studies. I felt terribly cheated. I had all these years of hard work, hard blinking."

On the other hand, Tombaugh never really emphasized to Slipher his desire to do further work on the question of galaxy distribution. After the 1937 paper in the *Publications of the Astronomical Society of the Pacific*, a paper whose production Slipher had supported, Tombaugh went back to blinking. Although he discussed the problem of the distribution of galaxies with Hubble, he did not emphasize the matter as much with Slipher. Thus, it may not be surprising that the director did not encourage Tombaugh to continue his analysis.

By the end of the war, Slipher's interests had turned away from basic research and it's entirely possible that he did not realize the importance of the galaxy statistics that Tombaugh had assembled. Tombaugh remembers that in his later days at the observatory, Slipher was "very aloof. He would work in his office and we didn't talk much." It's also possible that Tombaugh's own interest in the problem became more intense only after his 1946 discussion with Hubble, and even if he had reported it to Slipher on his return it might have been too late to change the director's mind.

Even if Tombaugh had reported his conversation with Hubble, would Slipher have taken Hubble's side anyway and ignored what Tombaugh's plates showed? "Hubble was the authority," Tombaugh emphasizes. "Anyone criticizing him in those days was sticking his neck out." Considering the esteem in which Hubble was, and is, held, Tombaugh may not even have mentioned to Slipher that he had argued with Hubble.

The whole episode resulted in a lost opportunity. Whatever Slipher's reason, his decision to ask Tombaugh to leave meant that the important work on galaxy distribution was never done at Lowell Observatory and that possibly the most significant outcome of all Tombaugh's years of work was never attained. "The counts were tabulated; I had a lot of ammunition ready to go when I was done blinking." It was ammunition still frozen in the plate emulsion. The great survey work would be left to Lick and Palomar, and the work of Fritz Zwicky and George Abell.

During Tombaugh's stay at Lowell, he found a total of 3,969 asteroids on the more than 350 photographic plates taken during the trans-Neptunian planet search. Possibly 775 of those asteroids had not been observed previously. He also discovered two comets, one nova, five open star clusters, several clusters of galaxies, one supercluster of galaxies, one globular star cluster, and one trans-Neptunian planet. "I wanted to find out for myself what was out there," says Tombaugh. Although he had expected to discover more planets, it was not a disappointment to him that he did not. "A lot of my happy years were there, and some of them were not so happy. But I certainly enjoyed observing and my heart was in it up to my ears."

The telescope Clyde Tombaugh used for 14 years stayed at Lowell, its long career not nearly over. Years later director Arthur Hoag claimed that with its many projects, the 13-inch telescope had become one of the world's most productive telescopes. It was never more productive than during Clyde Tombaugh's tenure, however, for he was a man who never quite gave up searching one more pair of plates for hidden treasure, a man who called himself a traveler "going over the next hill, with an eternal hope." ☐

This article is excerpted from a chapter in David H. Levy's biography, Planet Hunter: The Life of Clyde Tombaugh, to be published this spring by the University of Arizona Press.

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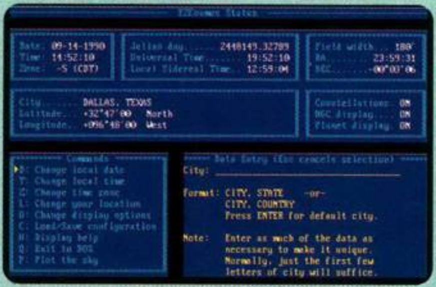

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EZCosmos Status

Date: 09-14-1990    Julian day....... 2448149.32789    Field width.... 180°
Time: 14:52:10      Universal Time....... 19:52:10    RA........ 23:59:31
Zone:  -5 (CDT)     Local Sidereal Time.. 12:59:04    DEC.......-00°00'06

City....... DALLAS, TEXAS                              Constellations.. ON
Latitude... +32°47'00   North                          NGC display.... ON
Longitude.. +096°48'00  West                           Planet display. ON

-------- Commands --------      ----- Data Entry (Esc cancels selection) -----
▶D: Change local date           City: ______________________________
 T: Change local time
 Z: Change time zone            Format: CITY, STATE    -or-
 L: Change your location                CITY, COUNTRY
 O: Change display options              Press ENTER for default city.
 C: Load/Save configuration
 H: Display help                Note:   Enter as much of the data as
 Q: Exit to DOS                         necessary to make it unique.
 P: Plot the sky                        Normally, just the first few
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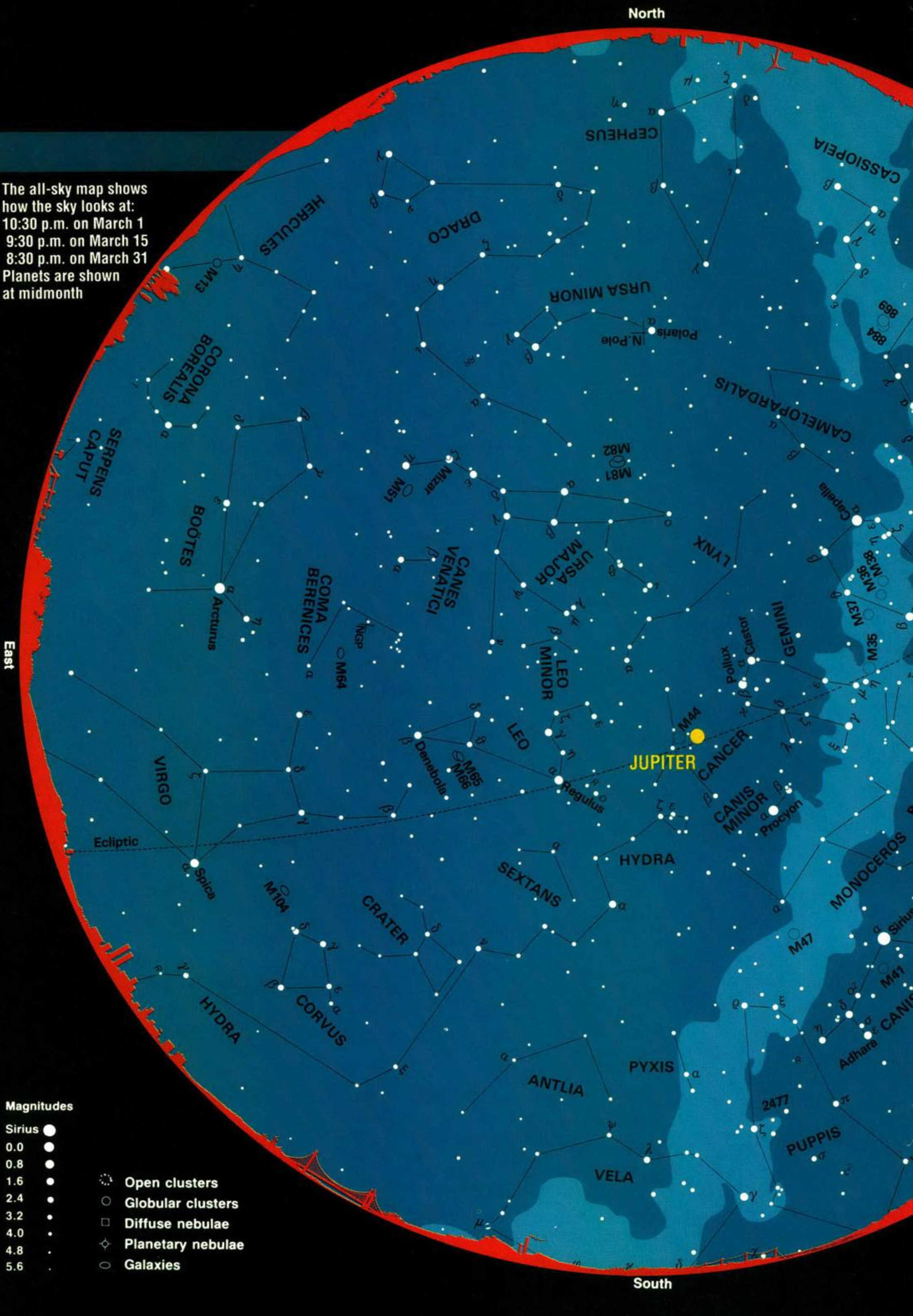
The all-sky map shows how the sky looks at:
10:30 p.m. on March 1
9:30 p.m. on March 15
8:30 p.m. on March 31
Planets are shown at midmonth


North
East
South
CEPHEUS
CASSIOPEIA
HERCULES
DRACO
M13
URSA MINOR
Polaris
N. Pole
869
884
CORONA BOREALIS
CAMELOPARDALIS
SERPENS CAPUT
M82
M81
Mizar
M51
Capella
BOÖTES
CANES VENATICI
URSA MAJOR
LYNX
COMA BERENICES
M36
M38
Arcturus
NGP
M37
GEMINI
M64
LEO MINOR
M35
Castor
Pollux
LEO
M44
JUPITER
CANCER
Denebola
M65
M66
VIRGO
Regulus
CANIS MINOR
Procyon
Ecliptic
HYDRA
MONOCEROS
SEXTANS
Spica
M104
CRATER
M47
Sirius
M41
CORVUS
HYDRA
CANIS
Adhara
ANTLIA
PYXIS
2477
PUPPIS
VELA
Magnitudes
Sirius
0.0
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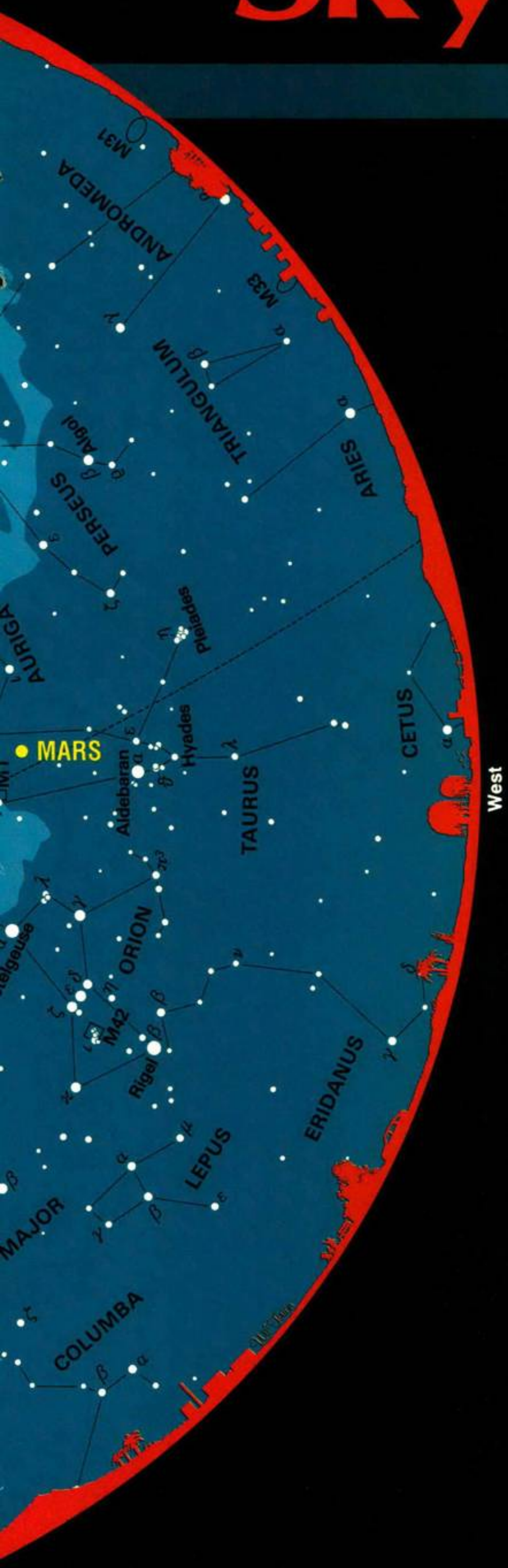
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

March 1991



Map Art by Wil Tirion

WATCH FOR INNERMOST MERCURY

Mercury puts in its best evening appearance of the year in the two-week period surrounding greatest elongation on March 27. Look for the normally elusive planet about 10° above the western horizon thirty minutes after sunset.

THE MOON COVERS THE PLEIADES

The waxing crescent Moon passes through the Pleiades star cluster on the evening of March 20, occulting many of the cluster's stars as seen from North America. Observers in the eastern part of the continent can see the entire event beginning shortly after sunset, while those in the western part can see only the end of the event.

PALLAS BRIGHT IN MARCH

The brightest asteroid of 1991 is Pallas, which reaches magnitude 6.7 when at opposition on March 6. Telescope owners in eastern North America also have the chance to witness a rare event on March 29/30, when Pallas occults a 9th-magnitude star.

Calendar of Events

1 Mercury is in superior conjunction

6 Pallas is at opposition

7 The Moon passes 0.8° north of Antares, 2 p.m. EST

8 Last Quarter Moon is at 5:32 a.m. EST
The Moon is at apogee (251,208 miles from Earth), 7:56 p.m. EST

12 The Moon passes 0.9° north of Saturn, 3 a.m. EST

16 New Moon is at 3:10 a.m. EST

17 The Moon passes 5° north of Mercury, 10 a.m. EST

18 The Moon passes 5° north of Venus, 7 p.m. EST

20 The Pleiades are occulted by the Moon, 7 p.m. EST
Vernal equinox is at 10:02 p.m. EST

21 The Moon is at perigee (229,845 miles from Earth), 11:38 p.m. EST

22 The Moon passes 0.7° north of Mars, noon EST

23 First Quarter Moon is at 1:03 a.m. EST

25 The Moon passes 1.6° south of Jupiter, 8 a.m. EST

27 Mercury is at greatest eastern elongation (19°)
The Moon passes 0.9° south of Pallas, 9 p.m. EST

30 Full Moon is at 2:17 a.m. EST

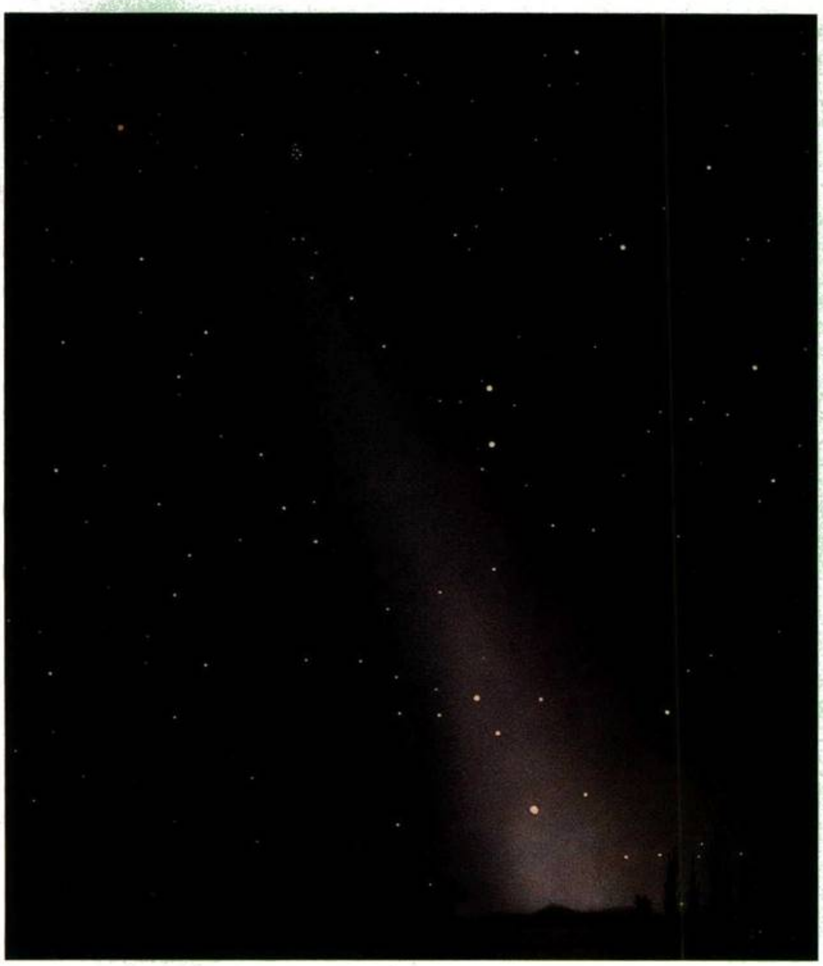
MERCURY BRIGHT IN THE EVENING SKY

The sky's most elusive bright planet, innermost Mercury, has its best evening apparition of the year this month. Look for it 30 to 45 minutes after the Sun sets, below and to the right of the brilliant planet Venus. Mercury is at greatest elongation — when it is farthest from the Sun for this evening apparition — on March 27. Even when farthest from the Sun, however, Mercury is low in the sky. At greatest elongation the planet is 19° from the Sun and lies 12° above the western horizon half an hour after sunset.

Mercury shines brightly, at magnitude –1.3, when it first comes into view in mid-March. By the time it disappears from view in early April, it has faded to magnitude 2.2. Yet during all this time, the planet is getting closer to Earth. Why does it appear fainter when it's closer? The answer is apparent to anyone who aims a telescope at it. As Mercury prepares to pass between the Sun and Earth, its lit half turns away from us. The dot of light we see with the naked eye is really shrinking to a tiny crescent, which reflects less light in our direction.

Mercury is relatively easy to see this month because the ecliptic — the path traveled by the Sun, Moon, and planets across our sky — stands nearly straight up with respect to the western horizon in the early evening. Objects on the ecliptic are higher in the evening sky than they would be otherwise and thus appear farther from the Sun's glare.

THE ETHEREAL GLOW of the zodiacal light subtly brightens the western evening sky during the first half of March. Sketch by E. Leopold Trouvelot.



THE ELUSIVE ZODIACAL LIGHT

This is also the best time of year to see the zodiacal light after sunset. It is a faintly glowing pyramid of light whose base rests on the western horizon, just at the place where the Sun went down an hour or so before. The light extends up toward a small, dipper-shaped grouping of stars, the Pleiades, or Seven Sisters. This year, the planet Venus shines in the midst of the zodiacal light, a brilliant beacon in contrast to the light's soft glow. Be sure to look in the first half of March, before the Moon returns to the evening sky and overwhelms the faint light.

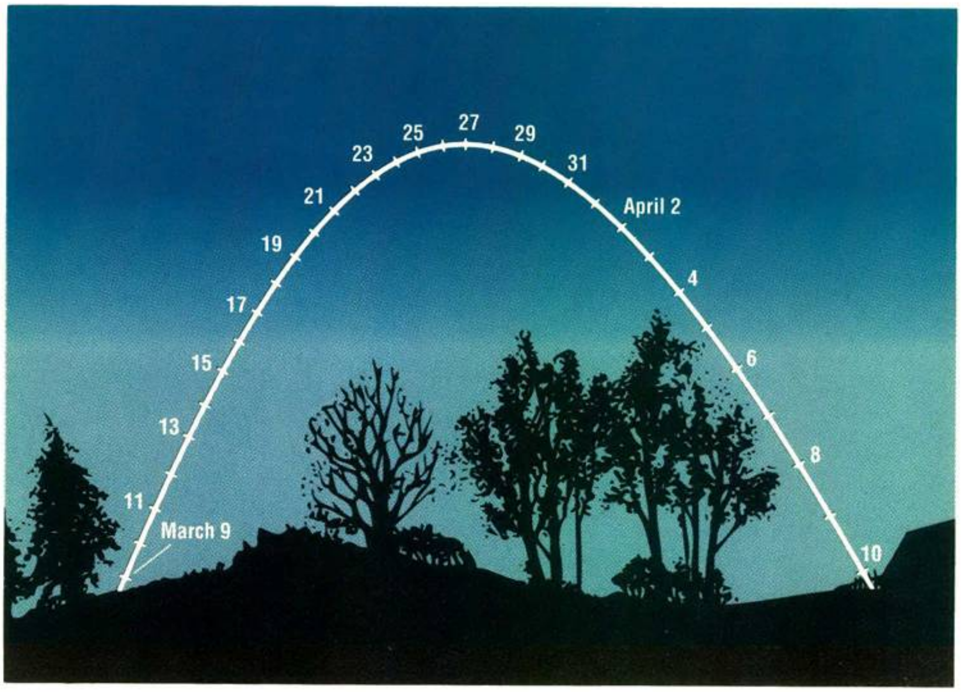
The zodiacal light is actually sunlight that has reflected off dust in the plane of the solar system, which is why the light follows the ecliptic. The steep angle of the ecliptic to the western horizon this month makes the light easier to see. The ecliptic stands up a little straighter seen from the southern United States than it does from the northern United States. I've noticed that people who live in the southwest often see the zodiacal light, while northern stargazers frequently say they've never seen it. But I suspect this has more to do with the darkness and purity of the desert skies than with anything else. From the vantage point of West Texas, I've seen the zodiacal light dozens of times. From there it's bright enough to be noticed easily, and people who don't know what it is are apt to ask about it.

Still, one's location on the globe makes a difference. In his 1909 book *Curiosities of the Sky*, Garrett Serviss described a view of the light from the tropics. He wrote, "It was the finest view of the Zodiacal Light that I had ever enjoyed — thrilling in its strangeness — but I was almost disheartened by the indifference of my guide, to whom it was a light and nothing more. If he had no science, he had less poetry…."

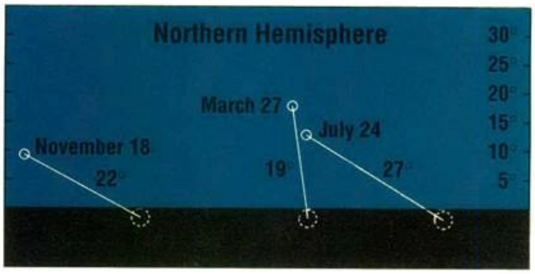
SEARCH FOR A YOUNG MOON

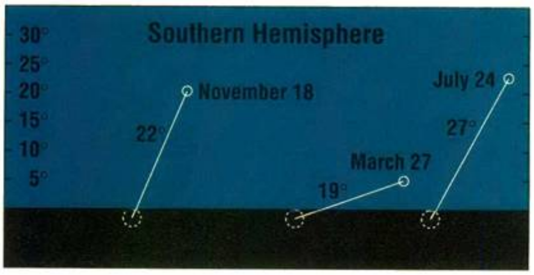
Finally, the steep angle of the ecliptic makes this month a good time to look for one of the most beautiful of all common sky objects: the young Moon. Stargazers often make a game of looking for the Moon as soon as possible after it is New, or between the Sun and Earth. The Moon is New on the night of March 15/16, and thus the evening of March 16 is ideal for a young Moon search. From the East Coast, the Moon is about 15 hours old after sunset on the 16th and your chances of seeing it are slim. But that's the fun of looking for it! West Coast observers have a better chance. By the time the Sun sets for those observers, the Moon has waxed to the ripe old age of 18 hours.

To find the young Moon on the evening of March 16, start looking just after sunset while the sky is still bright. An hour after sunset is too late. Use binoculars to scan along the western horizon. You'll see Venus shining brilliantly high in the sky. Mercury is below Venus, near the western horizon. The young Moon can be found about 7° to the lower right of Mercury. Good luck!



MERCURY IS AT ITS BEST in the evening sky during late March and early April. Look for the innermost planet low in the west about 30 minutes after the Sun sets; it reaches a peak elevation of 12° on March 27. Northern Hemisphere observers have a particularly good view of this elongation because Mercury lies almost directly above the Sun at sunset. Observers south of the equator will be hard-pressed to spot Mercury this month, but will have much better views later this year (below).





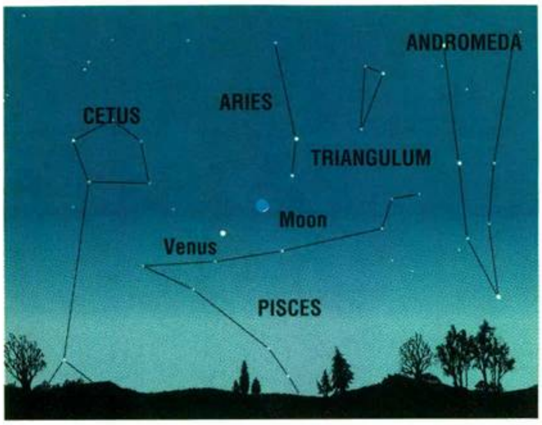
MARCH'S PLANETS

Venus is the brilliant object in the west after sunset. Each evening it competes with another planet, Jupiter, to be the first "star" to pop into view after the Sun goes down. Venus is brighter than Jupiter at magnitude –4.0. In fact, it's the brightest starlike object in the sky. But Jupiter is also bright and it shines in the southeast in early evening, against a dark sky background, while Venus is located in evening twilight. When darkness falls, which planet do you see first?

Mercury is behind the Sun as seen from Earth, in superior conjunction, on March 1/2. It comes into view low in the west after sunset during the second half of March. Don't mistake it for Venus. That planet is higher in the west and appears much brighter. At its greatest apparent distance from the Sun on March 27, Mercury is about 16° to the lower right of Venus.

Mars is high in the southwest during the early evening hours and sets not long after midnight. Mars is now falling far behind Earth in its larger and slower orbit around the Sun, and as a result it is fading in brightness. By mid-March it has faded to magnitude 0.8. Mars is now moving eastward in front of the stars, but it isn't yet covering much ground, especially compared with the rapid motion it'll exhibit in the months to come. It remains in the constellation Taurus throughout March.

Jupiter shines brightly in the southeast at nightfall. It remains in the



THE MOON AND VENUS form a pretty pair in the west after the Sun goes down on March 18.

come. It remains in the constellation Taurus throughout March.

Jupiter shines brightly in the southeast at nightfall. It remains in the sky nearly all night, setting a couple of hours before the Sun rises. Although it has now faded a bit to magnitude –2.4, giant Jupiter easily outshines all other objects in the night sky except the Moon and Venus.

Saturn is the only planet visible just before sunrise this month. It can be seen in the southeast before dawn among the stars of Capricornus. Although it is rather inconspicuous at magnitude 0.7, Saturn will grow brighter over the coming months as it approaches its opposition in July.

THE STARRY SKY

If you are in the country this month, perhaps searching for the glowing zodiacal light or attempting to catch a glimpse of elusive Mercury, look for a glittering star called Alphard ascending in the southeast. This star is also known as Cor Hydrae, the heart of the snake in the constellation Hydra.

Alphard isn't the brightest star in the sky. But, as seen in a dark country sky, it's fairly bright at magnitude 2.0. It's also noticeable for its reddish or yellowish color. It is a giant star that astronomers estimate is 85 light-years from Earth.

If you live in the suburbs, you should be able to see Alphard from your backyard. The rest of its constellation, however, requires a dark sky to be seen. Look for Hydra as it stretches up from the southeastern horizon during the evening hours this month.

The name Alphard means "solitary one." It was given this name not only because there are no other bright stars in its immediate vicinity of sky, but also because, in all of Hydra's length, it is the only star of any brightness.

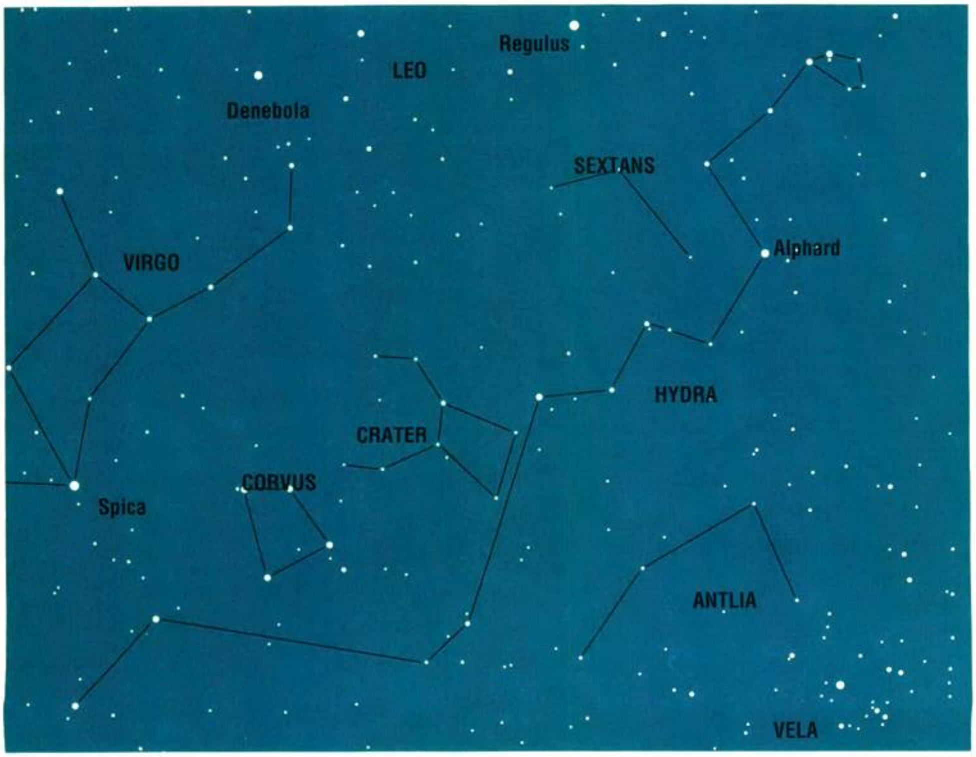
And Hydra is long! It is the longest of the 88 constellations. Its stars require more than six hours to cross the meridian, the line that divides the sky in half from due north to due south.

There are many fascinating legends associated with Hydra. In a famous Greek legend, Hydra is a monster with a hundred heads. If one head was cut off, two would grow in its place. Hercules is said to have killed Hydra by searing the stumps of its heads with hot iron.

In another Greek legend, Hydra is the water snake carried to the Sun-god Apollo by a lazy crow named Corvus. Apollo had sent Corvus for a cup of fresh spring water, but when he got to the spring, Corvus found it so pleasant that he dawdled there, eating figs, for days.

Then the day of reckoning came, and Corvus knew he'd have to face Apollo. He grasped a nearby water snake in his claws and carried it to the god, claiming that the serpent had attacked him. But Apollo wasn't easily fooled. He angrily flung the crow, the cup and the serpent out of heaven and into the sky. Today we see the constellation Hydra carrying both Corvus the Crow and Crater the Cup with it around the heavens. □

Deborah Byrd is the creator, writer, and producer of "Star Date," an independently syndicated daily radio series on commercial and public radio.



HYDRA THE SEA SERPENT is the longest of the sky's 88 constellations and takes more than 6 hours to cross the meridian. You can see all of the mighty serpent by looking toward the south and southeast late on March evenings.

Through the Eyepiece *by* Rick Shaffer

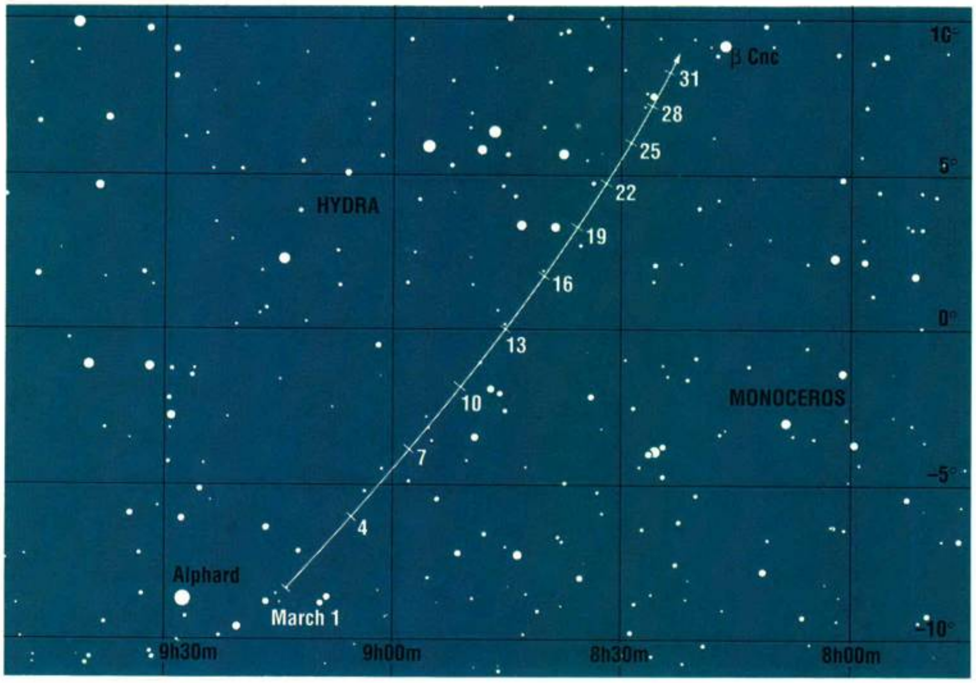
A LAST LOOK AT LEVY

It's been quite a while since we've had a comet that has remained bright for as long as Comet Levy has. Levy has been brighter than 10th magnitude, and thus well within the range of backyard telescopes 4 inches in aperture or larger, since it was discovered in May 1990. The only time it has been hidden from view was late last year, when it lay near the Sun in the sky.

Now, however, Levy is pulling rapidly away from both the Sun and Earth and is quickly fading from view. In fact, March is the last month you'll be able to get a good view of the comet during this apparition. By the beginning of April, astronomers expect Comet Levy to be fainter than 10th magnitude.

Fortunately, during March the comet is better placed in the evening sky than it has been for several months. On the 1st, Levy lies about 20° above the southeastern horizon when evening twilight ends. Look for the faint, fuzzy object about 4° to the west of the 2nd-magnitude star Alphard in the constellation Hydra.

As the month progresses, Levy moves to the northwest, passing just west of the head of Hydra and then into southern Cancer by month's end. But the Moon is waxing toward Full during the latter half of March and its light makes the comet much harder to see. Your last good chance to view Comet Levy should come around the middle of the month.



COMET LEVY REMAINS VISIBLE in backyard scopes during March, appearing higher in the evening sky as it moves northward through Hydra into Cancer. Positions are shown at 11 p.m. EST (10 p.m. CST, 9 p.m. MST, and 8 p.m. PST).

JUPITER'S SATELLITES CONTINUE THEIR SHOW

If searching out 10th-magnitude objects isn't your cup of tea, Jupiter may offer the kind of observing experience you're after. The solar system's largest planet, which shines at magnitude –2.4 and measures 43" across its equator, has something to please almost every observer. And this month, the giant planet is particularly appealing because it is high in the evening sky.

You can begin observing Jupiter as soon as the sky grows dark in the evening. Jupiter is already high in the east as twilight fades and continues to climb until mid-evening. The giant planet reaches its highest point in the sky around 9 p.m. local time, when it lies only 20° from the zenith for an observer at 40° north latitude. And Jupiter doesn't set until the wee hours of the morning, so if you're inclined to do so, you can observe the planet for most of the night.

The first thing you'll likely notice is the wealth of detail in the planet's banded atmosphere. The two most prominent features are the North and South Equatorial Belts, the latter having returned to prominence only recently. In addition, if the correct hemisphere is pointing toward Earth, you should be able to catch a glimpse of the planet's Great Red Spot. Although the spot is actually more pinkish than red, it can usually be seen when facing our way.

But this month, like the past few, really belongs to Jupiter's Galile-

COORDINATES FOR COMET LEVY

Date	R.A. (2000)	Dec.
Mar. 1	9h14.0m	–8°21'
Mar. 4	9h05.6m	–6°01'
Mar. 7	8h58.1m	–3°50'
Mar. 10	8h51.4m	–1°48'
Mar. 13	8h45.6m	0°03'
Mar. 16	8h40.5m	1°46'
Mar. 19	8h36.0m	3°20'
Mar. 22	8h32.2m	4°46'
Mar. 25	8h28.9m	6°04'
Mar. 28	8h26.2m	7°15'
Mar. 31	8h23.9m	8°20'

MUTUAL EVENTS OF THE GALILEAN SATELLITES

Date	Begin Time	End Time	Event	Type of Event	Light Loss	Distance
Mar. 2	5h00m	5h28m	Callisto Eclipses Europa	Partial	8%	3
Mar. 6	7h49m	7h56m	Europa Occults Io	Partial	27%	6
Mar. 6	9h12m	9h19m	Europa Eclipses Io	Annular	60%	5
Mar. 10	3h37m	3h49m	Europa Eclipses Callisto	Partial	25%	4
Mar. 13	10h00m	10h06m	Europa Occults Io	Partial	20%	6
Mar. 13	11h32m	11h39m	Europa Eclipses Io	Annular	57%	5
Mar. 17	0h42m	0h49m	Europa Eclipses Io	Annular	55%	5
Mar. 17-18	21h50m	2h14m	Callisto Eclipses Ganymede	Partial	11%	10
Mar. 24	1h18m	1h22m	Europa Occults Io	Partial	12%	5
Mar. 24	3h01m	3h08m	Europa Eclipses Io	Partial	49%	4
Mar. 29	6h13m	6h22m	Io Eclipses Ganymede	Partial	1%	4
Mar. 31	3h30m	3h34m	Europa Occults Io	Partial	7%	5
Mar. 31	5h20m	5h26m	Europa Eclipses Io	Partial	42%	4

Begin Time: Universal time at beginning of event. (Subtract 5 hours to convert to EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.) **End Time:** Universal time at end of event. **Event:** The nature of the event and the satellites involved. **Type of Event:** Whether the event is partial, total, or annular. **Light Loss:** For eclipses — the percent of light lost by the eclipsed satellite at midevent; For occultations — the percent of light lost from the combined light of both satellites at midevent. **Distance:** The apparent distance of the satellite from Jupiter's center in Jovian equatorial radii.

MANY MORE MUTUAL EVENTS are on the agenda this month for observers of Jupiter's Galilean satellites. Thirteen of these eclipses and occultations can be seen from North America.

an satellites. The four brightest moons of Jupiter continue to occult and eclipse one another as Earth passes through the plane of the satellites' orbits. (See "Watch Jupiter's Moons Play Tag" in the January 1991 issue for details on observing all of the satellites' mutual events.)

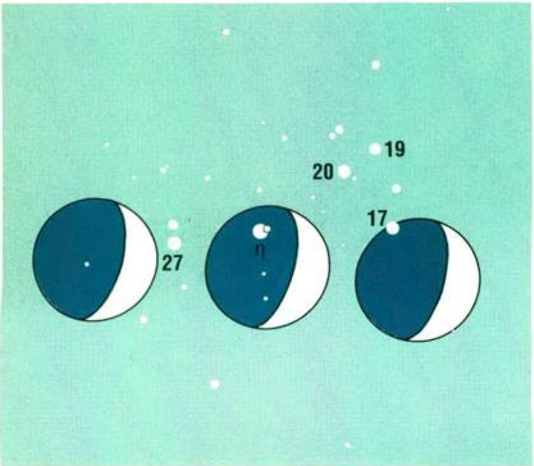
All four Galilean satellites participate in at least one mutual event that is visible from North America this month (see table at left). Perhaps the best of the lot occurs on the night of March 5/6. Beginning at 9h12m UT on the 6th (4:12 a.m. EST, 1:12 a.m. PST) Europa eclipses Io. This annular eclipse lasts for just 7 minutes, but Io loses 60 percent of its brightness at mid-eclipse. This eclipse follows close on the heels of a Europa occultation of Io. From 7h49m to 7h56m UT (2:49 a.m. to 2:56 a.m. EST, 11:49 p.m. to 11:56 p.m. PST on the 5th), the combined light of the pair drops by 27 percent as Europa passes in front of Io.

THE HIDING OF THE PLEIADES

One of the prettiest sights you can see in a rich-field telescope is the Moon passing through a star cluster. The Moon does just that this month with the Pleiades, probably the best such cluster for an occultation because it is so large and its stars so bright.

On the evening of March 20, the waxing crescent Moon traverses the southern part of the Pleiades for observers in eastern North America. The peak of the occultation occurs around 7 p.m. EST, just as the sky is growing dark. That's one of the reasons why West Coast observers won't get as good a show: by the time the Sun sets there, most of the occultation is over. Nevertheless, observers throughout North America should have a fine view of the crescent Moon lying near the Pleiades after darkness falls on the 20th.

PASSING THROUGH THE PLEIADES on the evening of March 20, the crescent Moon occults the cluster for observers in eastern North America. This view shows the Moon at 90-minute intervals beginning at 6:00 p.m. EST (right) as seen from Boston.



TELESCOPIC PLANETS

Mercury's best evening apparition of 1991 occurs in the latter half of March. The innermost planet's telescopic appearance undergoes a rapid change during these two weeks, growing larger in apparent size as its phase shrinks.

You can start to look for Mercury around the middle of March, when it lies low in the west about 30 minutes after sunset. On the 15th, the planet shines at magnitude –1.3 and its 5.6"-diameter disk is 88-percent illuminated. At greatest elongation on March 27, Mercury is larger (7.5" in apparent diameter), thinner (42-percent lit),and fainter (magnitude –0.1). As March turns into April, the planet measures 8.3" across, is 29-percent lit, and shines at magnitude 0.6.

Locating Venus in the western evening sky is much easier than finding Mercury because Venus is so much brighter at magnitude –4.0. But Venus is relatively boring compared with Mercury because its appearance is changing so slowly. As Venus comes closer to Earth this spring and summer, however, it will mimic Mercury's behavior this month. In the meantime, Venus measures 12.4" in apparent diameter and is 85-percent lit this month.

Mars is but a shadow of its former self in March. The Red Planet measures just 7" across its equator and shines relatively faintly at magnitude 0.8. That's a far cry from its November highs of 18" in diameter and a magnitude of –2.0.

Last month I exhorted you to get out and observe Saturn's unusually active atmosphere, and that advice holds true for this month too. The Great White Spot, which appeared unexpectedly in September 1990, is still noticeable as a white band across Saturn's mid-section as we go to press in mid-December. The white feature may not be there come March, but you won't know for sure until you take a look. If the spot, or what's left of it, is there, it will appear on the 0.7-magnitude, 16"-diameter disk of the planet.

ASTEROIDS IN THE EYEPIECE

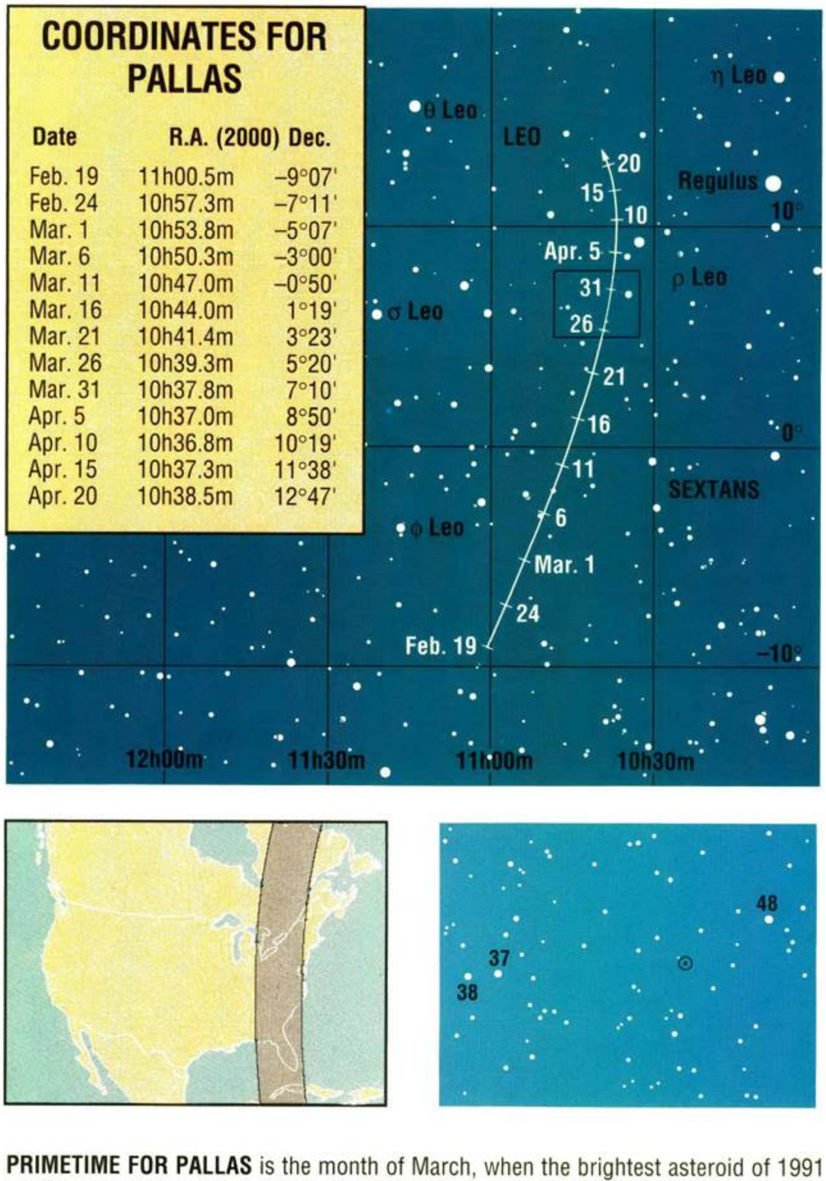
The minor planet Pallas experiences an extraordinary March, in which it becomes the brightest asteroid of 1991 and occults a 9th-magnitude star. First, Pallas reaches opposition on March 6 among the stars of eastern Sextans. On that date, the 380-mile-wide asteroid shines at magnitude 6.7, making it brighter than any other asteroid during 1991.

But perhaps even more significantly, Pallas occults the 9th-magnitude star AGK3 +06°1336 on the night of March 29/30. At 5h56m UT on the 30th (12:56 a.m. EST), Pallas passes in front of the star, covering it for observers along much of North America's East Coast. (See the diagram and map at right for the location of the star and the approximate path of the asteroid's shadow, though be forewarned that the shadow's path could be off slightly.) The combined light of Pallas and the star drops by 0.2 magnitude during the occultation, and along the center of the path the occultation lasts for 36 seconds. (For more information on observing asteroid occultations, see "Stand in the Shadow of an Asteroid" in the January 1991 issue.) ☐

Rick Shaffer is a technical group leader at the Jet Propulsion Laboratory in Pasadena, California. He leads the data management team on the Ulysses mission, which is on its way to Jupiter and ultimately the Sun.

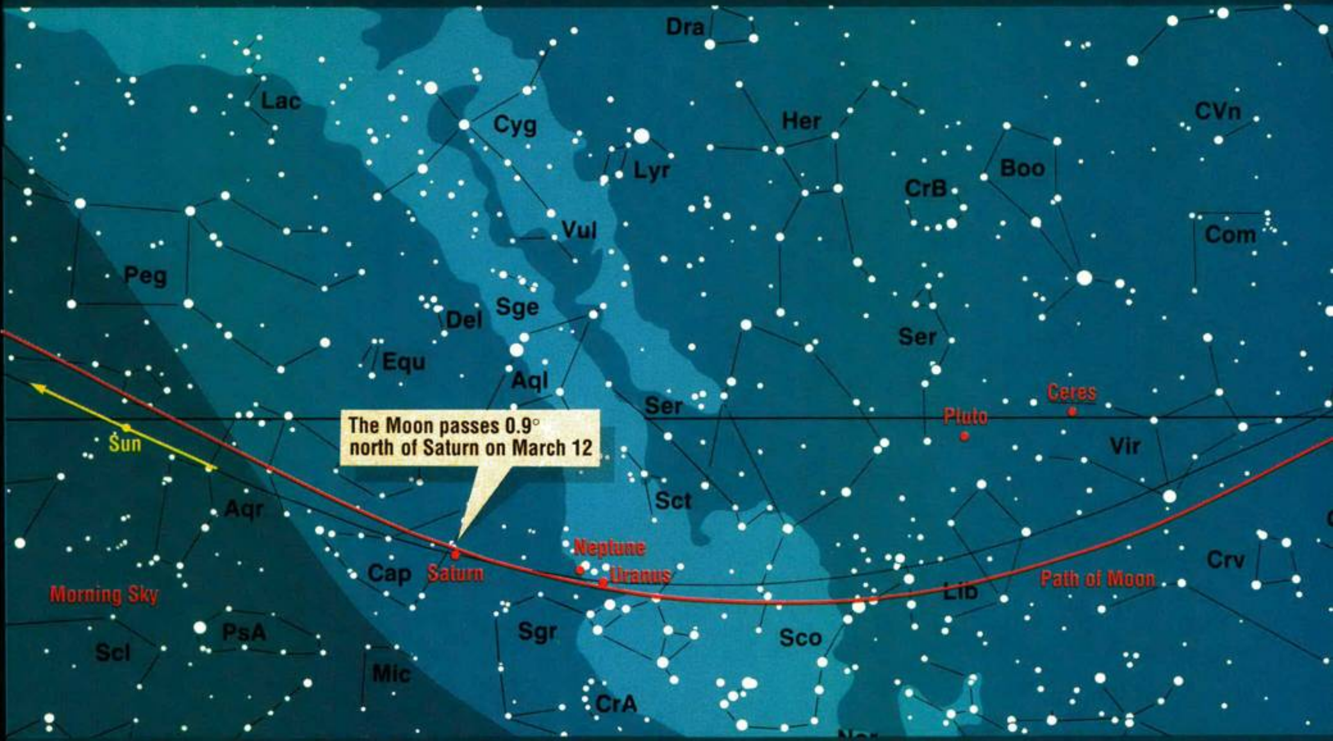
COORDINATES FOR PALLAS

Date	R.A. (2000)	Dec.
Feb. 19	11h00.5m	–9°07'
Feb. 24	10h57.3m	–7°11'
Mar. 1	10h53.8m	–5°07'
Mar. 6	10h50.3m	–3°00'
Mar. 11	10h47.0m	–0°50'
Mar. 16	10h44.0m	1°19'
Mar. 21	10h41.4m	3°23'
Mar. 26	10h39.3m	5°20'
Mar. 31	10h37.8m	7°10'
Apr. 5	10h37.0m	8°50'
Apr. 10	10h36.8m	10°19'
Apr. 15	10h37.3m	11°38'
Apr. 20	10h38.5m	12°47'



PRIMETIME FOR PALLAS is the month of March, when the brightest asteroid of 1991 reaches opposition and occults a 9th-magnitude star. Pallas moves from Sextans into Leo this month and remains in Leo through April (top). Positions are shown at 11 p.m. EST (10 p.m. CST, 9 p.m. MST, and 8 p.m. PST). On the night of March 29/30, Pallas passes in front of the star AGK3 +06°1336 (close-up, above right), occulting it for observers in much of eastern North America (above left).

The Solar System March 1991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Sun
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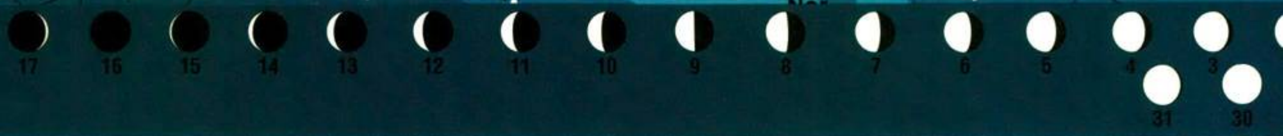
Pluto
Ceres
Vir
Aqr
Sct
Neptune
Uranus
Cap
Saturn
Crv
Morning Sky
Lib
Path of Moon
PsA
Sgr
Sco
Scl
Mic
CrA

The Moon passes 0.9° north of Saturn on March 12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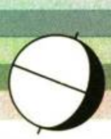
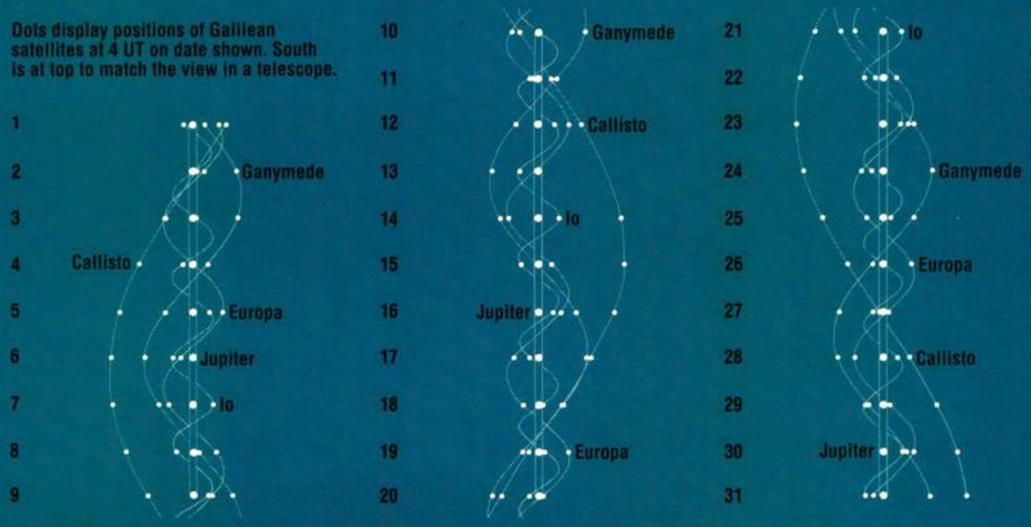
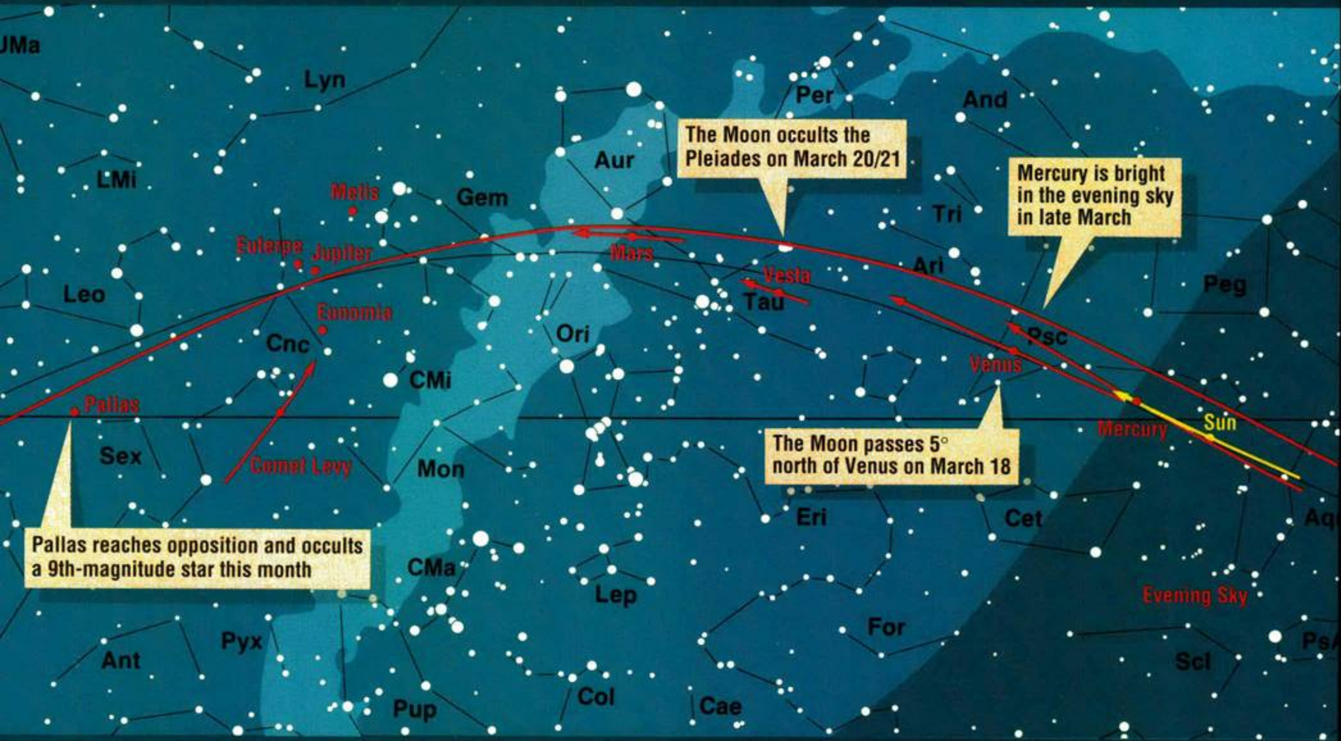
Planet	MERCURY	MERCURY	VENUS	MARS
Date	March 15	March 31	March 15	March 15
Magnitude	–1.3	+0.6	–4.0	+0.8
Angular Size	5.6″	8.3″	12.4″	6.9″
Illumination	88%	29%	85%	90%
Distance (AU) from Earth	1.211	0.807	1.351	1.356
Distance (AU) from Sun	0.315	0.342	0.721	1.630
Right Ascension (2000.0)	0h22.1m	1h38.9m	1h34.4m	5h17.5m
Declination (2000.0)	2°20′	13°26′	9°39′	25°09′



Jupiter's Moons

Dots display positions of Galilean satellites at 4 UT on date shown. South is at top to match the view in a telescope.




UMa
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Jupiter
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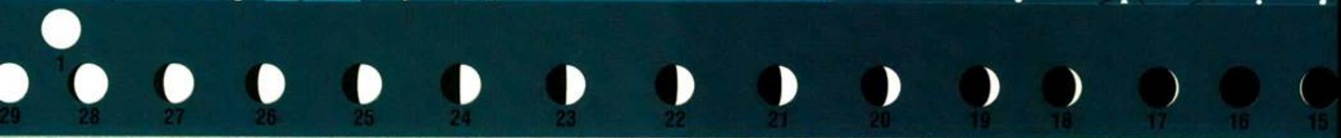
Eunomia
Cnc
Ori
Psc
Venus
CMi
Pallas
Mercury
Sun
Sex
Comet Levy
Mon
Eri
Cet
Aq
CMa
Lep
Evening Sky
For
PsA
Pyx
Ant
Scl
Pup
Col
Cae

The Moon occults the Pleiades on March 20/21

Mercury is bright in the evening sky in late March

The Moon passes 5° north of Venus on March 18

Pallas reaches opposition and occults a 9th-magnitude star this month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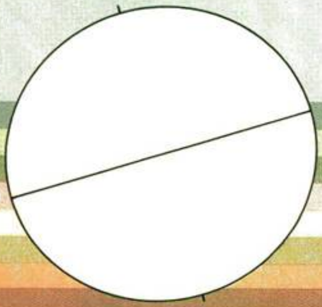
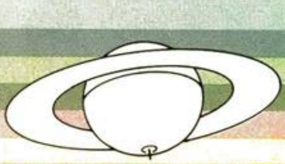
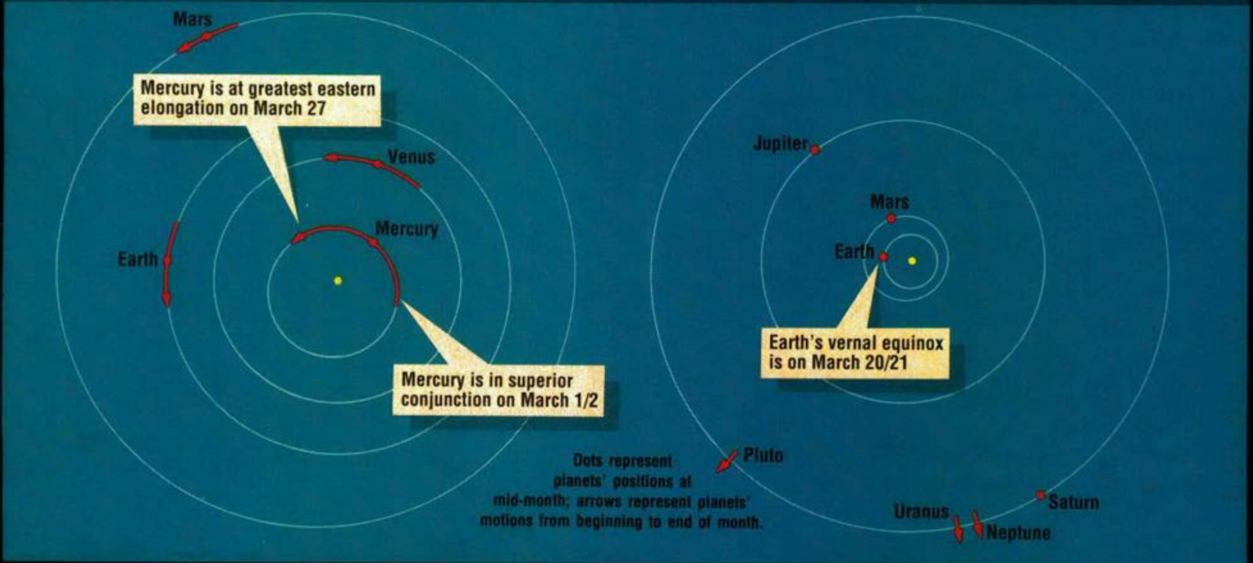




JUPITER March 15	SATURN March 15	URANUS March 15	NEPTUNE March 15	PLUTO March 15
−2.4	+0.7	+5.7	+8.0	+13.7
42.7"	15.6"	3.5"	2.2"	0.1"
99%	100%	100%	100%	100%
4.611	10.590	19.766	30.568	29.127
5.306	9.982	19.458	30.201	29.670
8h26.3m	20h25.2m	18h58.5m	19h11.4m	15h28.0m
20°01'	−19°30'	−23°06'	−21°38'	−2°54'

The Planets in Their Orbits


Mars
Venus
Mercury
Earth
Jupiter
Mars
Earth
Pluto
Uranus
Neptune
Saturn

Mercury is at greatest eastern elongation on March 27

Mercury is in superior conjunction on March 1/2

Earth's vernal equinox is on March 20/21

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

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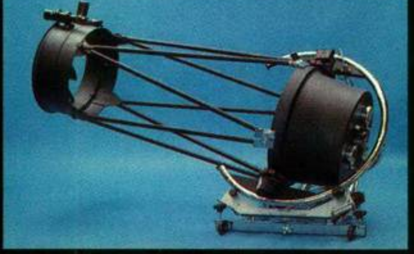

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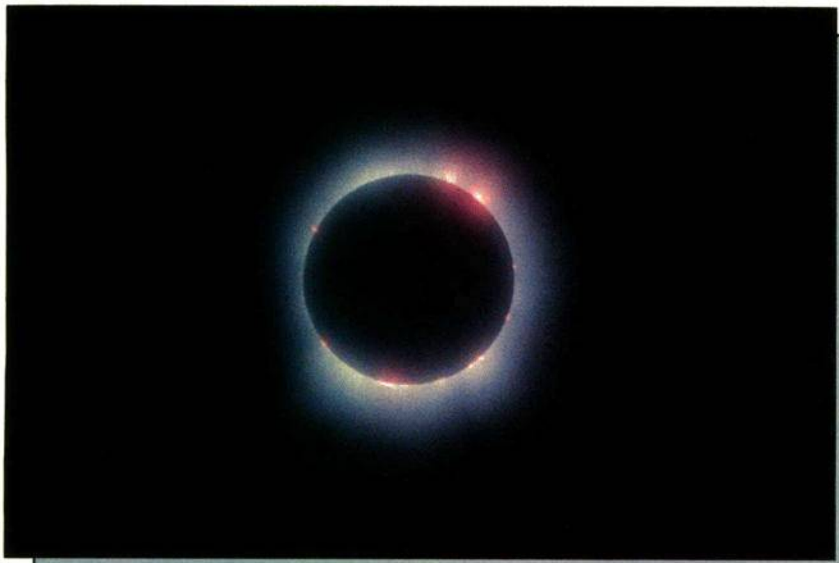
REMEMBERING JULY'S SOLAR ECLIPSE

"It was a screwball idea," remembers veteran eclipse chaser Stephen Edberg. "My eclipse-chasing friend David Levy and I decided that if we couldn't get to see totality during the July 21 eclipse we would at least have to see it as a partial eclipse. I can't say how many miles we would have had to travel to see a partial eclipse that day but the 133 miles we did travel — in quest of absolute last contact — paid off handsomely."

Edberg and Levy trekked from La Canada, California, to the hot, empty, earthquake-beaten Carrizo Plain of central California. "The idea for a stunt like this came in 1986," says Edberg, "when I suggested to David that we run out to the Mexico-Arizona border to see the tiny nibble of partial eclipse visible from there at high noon on October 3. David made it there successfully despite having received a speeding ticket on the way."

Last year Edberg concluded that he would not be able to travel to totality for last July's eclipse. "As I contemplated the map showing the partial eclipse phases," Edberg recalls, "I realized that a challenging alignment would occur and I could be a part of it. A completely new challenge occurred to me: How little could I travel from home and still see the partial eclipse before it slipped below the horizon at sunset? The maps I had only hinted at the answer. I ended up using my calculator with some eclipse prediction software that allowed me to make a somewhat more accurate prediction of where to go to see the minimum eclipse."

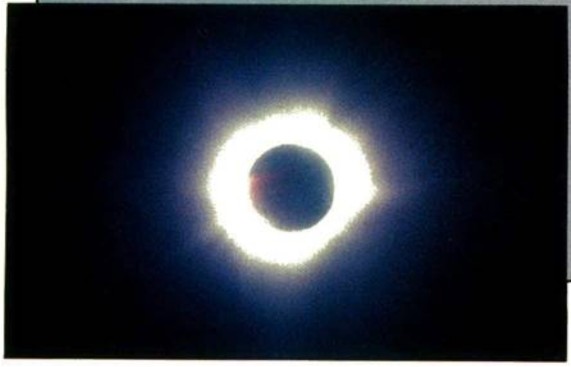
On July 21 Edberg and Levy found themselves rolling down Highway 58 toward the Carrizo Plain. "It was clear that we wouldn't make it in time to the top of the mountain I had selected as the observing site," says Edberg. "We simply stopped along the road. Sunset would occur at 8:09 p.m. By 8:03 I was getting nervous. Where was the Moon's nibble? Did we come up short? Wait! There it is — but it's on both sides of the Sun. We realized an atmospheric layer was distorting the Sun's limb. What's that notch? It was 8:06 and the Moon was taking a bite out of the Sun. We had done it! I'll always remember that race across the hot plain to join a vast celestial alignment." — *David J. Eicher.*



JULY 11'S SOLAR ECLIPSE brought a spectacular sight for those relative few who traveled to Finland to see it. All photos on this page are by Patrick Martinez.

A SNAPSHOT FROM AN AIRPLANE, this photo shows the naked-eye view from the eclipse-chasing aircraft Martinez and his companions flew over Finland.

THE SUN'S INNER CORONA is visible in this portrait made near mid-totality. This beauty is what causes eclipse chasers to travel such great distances.

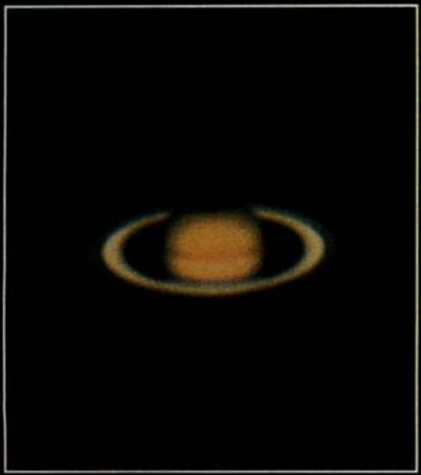


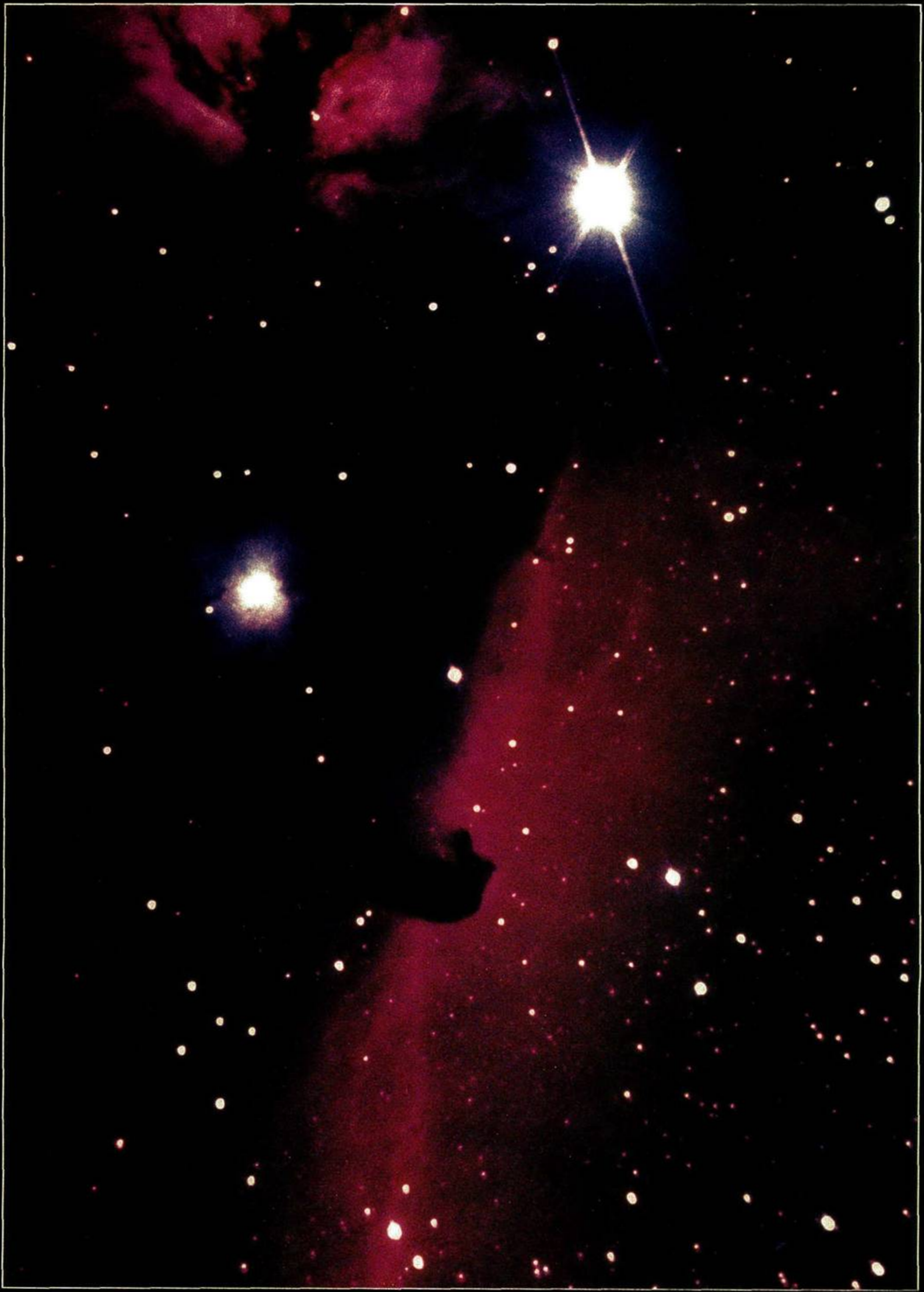
WINTER'S DARK AND ELUSIVE HORSEHEAD NEBULA

The Horsehead Nebula in Orion is one of the most difficult objects for visual observers and one of the most beloved objects for astrophotographers. Bill and Sally Fletcher's photograph of the Horsehead (opposite page) shows the dark nebula spectacularly well and nets this month's $100 "Best Astrophoto" award. The Fletchers used a 16-inch f/5 reflector and hypersensitized Konica 1600 film.

In the wake of last summer's impressive Comet Levy, astrophotographers jumped on Comet Tsuchiya-Kiuchi after its discovery last autumn. Michael Stecker's photo of the comet on November 17 shows the comet forming a triangle with two bright stars (right). Stecker used a Takahashi 8-inch f/4 scope and hypered Tech Pan film. On October 22 Jeffrey L. Jones recorded the same comet (below right). Jones used an 8-inch f/10 SCT, hypered Tech Pan, and a 15-minute exposure.

Last winter observers turned their heads toward Saturn once again, largely because of the planet's white spot activity. Last July, before the white spot eruption, Dan Schecter recorded the ringed planet with a 14-inch f/11 SCT and Fujichrome 100 film (below).





SUMMER'S RUDDY LAGOON AND TRIFID NEBULAE

Hallmarks of the summer Milky Way, the Lagoon and Trifid nebulae are favorites for visual and photographic observers alike. California astrophotographers Tony Hallas and Daphne Mount preserved the subtle reds and blues of the nebulae in a photograph made last autumn (above, opposite page). Hallas and Mount used a 6-inch f/7.5 EDF refractor, hypered Fujichrome Super HG 400 film, and a 60-minute exposure.

Last summer Charles Crauford of Beaumont, Texas (latitude: 30° N), made the ultimate test of clear horizons: he photographed the Eta Carinae Nebula (declination: -60°) as it skimmed over his treetops, marked by an arrow (opposite page, left). Crauford calculated when the nebula would cross the meridian and made a 3-minute exposure on Agfachrome 1000 with a 50mm f/2.8 lens centered on the time of meridian passage. The following night Crauford used a 10-inch reflector and Konica 3200 film for a 15-minute closeup exposure of the nebula (opposite page, right). The streaked trees are visible as dark patches along the bottom of the image.

Martin Guth's photograph of a breathtaking auroral display was less challenging but yielded gorgeous results (top). Last August Guth used a 28mm lens at f/2.8, Kodak VRG 1600 film, and a 20-second exposure.

The greatest challenge for solar system observers last August was spotting the very young Moon. James R. Brunkella of Thousand Oaks, California, recorded an hours-old Moon at 7:55 p.m. PDT on August 21 (above). Brunkella used a 5.5-inch Schmidt-Newtonian telescope, T-Max 100 film, and a 1/30-second exposure.

Core of the Virgo Cluster
Anglo-Australian Telescope Board photo

Explore the Virgo Cluster

A small telescope is all you need to seek out numerous residents of the densest cluster of galaxies visible in our sky.

by Alan Goldstein

The constellation Virgo represents a comet hunter's nightmare. Nowhere can you observe a greater concentration of galaxies — big and small, bright and faint, elliptical and spiral. The 18th-century comet hunter Charles Messier cataloged no fewer than a dozen galaxies in central Virgo and six more in a 15° radius from that spot. However, although he found quite a few, Messier also missed plenty of galaxies.

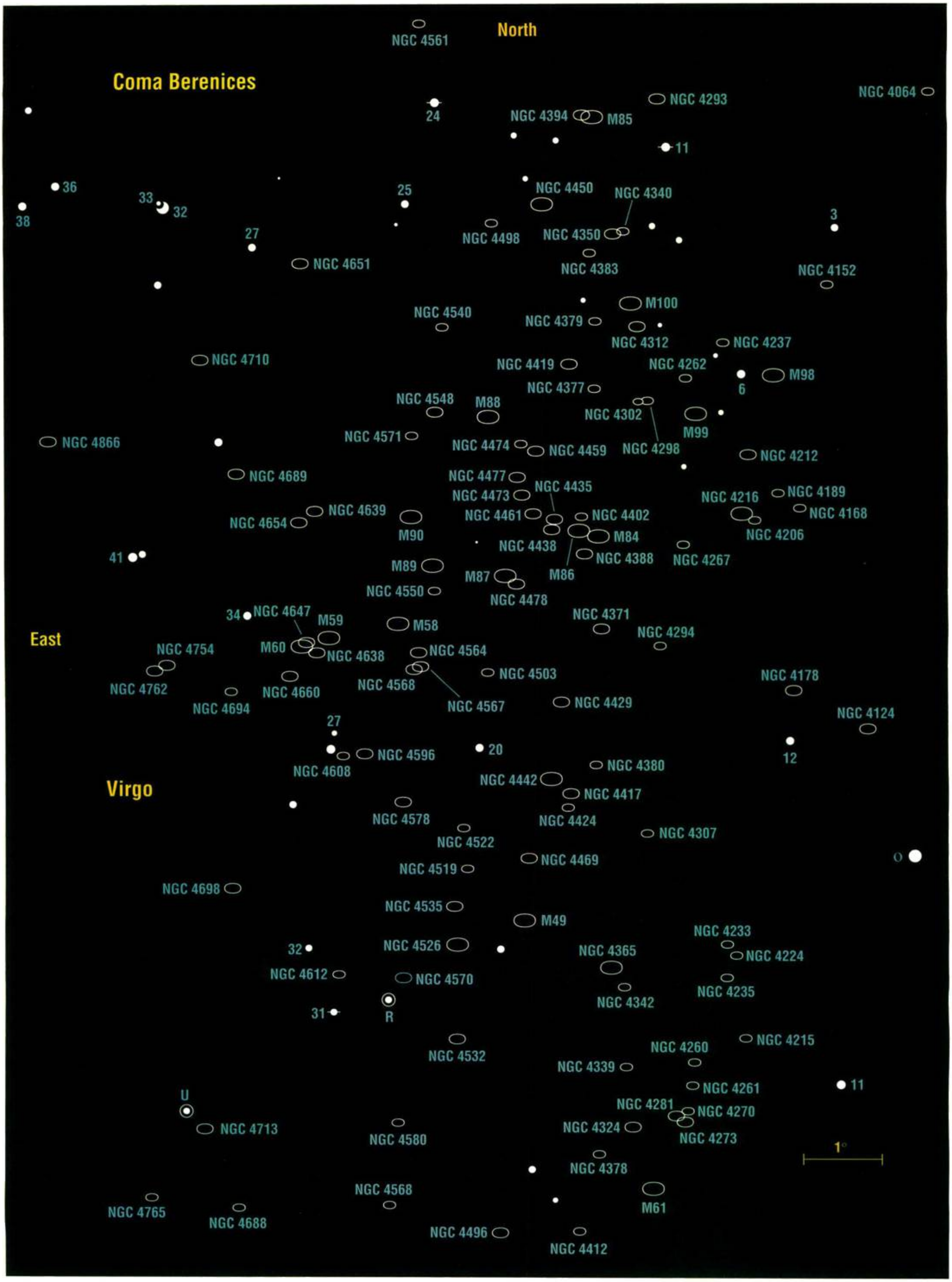
Virgo contains so many galaxies the renowned astronomer Edwin Hubble called the area the Realm of the Galaxies. Hubble and his colleagues found that so many galaxies are visible in this area because in Virgo (and neighboring Coma Berenices) we are seeing the largest cluster of galaxies in our part of the universe. The so-called Coma-Virgo cluster is part of a supercluster, an enormous association of galaxy clusters, to which our own Milky Way is a distant member.

Spiral and elliptical galaxies dominate the Virgo Cluster. Several Virgo galaxies are huge — dwarfing our Milky Way, with its diameter of 100,000 light years. Consequently, you'll be amazed at how many galaxies you can see in this region, even with a pair of binoculars under dark skies. Telescopes in the 2.4- to 6-inch range reveal a large number of galaxies in Virgo. In some places a 6-incher shows five galaxies within a single field. Seven- to 10-inch scopes show even more galaxies. Telescopes 12-inches or larger in diameter are most effective at picking up the myriad of faint members of the Coma-Virgo cluster; these telescopes also show details such as arm structure in the brightest and largest Virgo galaxies.

Describing all galaxies in the Virgo Cluster visible with small telescopes is beyond the scope of this article. Instead, we'll examine only the best and brightest of them. You can find more by checking *Sky Catalogue 2000.0* or *Burnham's Celestial Handbook.*

Our first galaxy is **NGC 4216**. At magnitude 10.4, NGC 4216 is certainly bright enough to have been picked up by Charles Messier. He did not record it, but you can see it in a small telescope or good pair of binoculars under very good skies. It is a large Sb spiral galaxy seen in profile. The galaxy's nucleus, which is bright and condensed, has a bright star about 1' east of center. NGC 4216 is one of the best edge-on galaxies in the region, but is usually overshadowed by M104 to the south and NGC 4565 to the north.

There are many spiral galaxies in Virgo. One of


NGC 4561
North
Coma Berenices
NGC 4293
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NGC 4498
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NGC 4651
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NGC 4152
M100
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NGC 4710
NGC 4419
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M88
NGC 4302
M99
NGC 4571
NGC 4866
NGC 4474
NGC 4459
NGC 4298
NGC 4212
NGC 4689
NGC 4477
NGC 4435
NGC 4473
NGC 4216
NGC 4189
NGC 4639
NGC 4461
NGC 4402
NGC 4168
NGC 4654
M90
M84
NGC 4206
NGC 4438
41
NGC 4388
NGC 4267
M89
M87
M86
NGC 4550
NGC 4478
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NGC 4647
M59
NGC 4371
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East
NGC 4294
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M60
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Virgo
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NGC 4578
NGC 4424
NGC 4522
NGC 4307
o
NGC 4469
NGC 4519
NGC 4698
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M49
NGC 4233
32
NGC 4526
NGC 4365
NGC 4224
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31
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NGC 4532
NGC 4260
NGC 4339
NGC 4261
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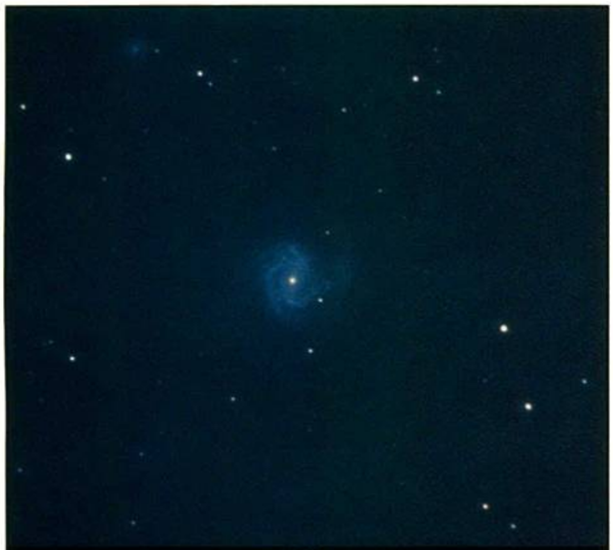
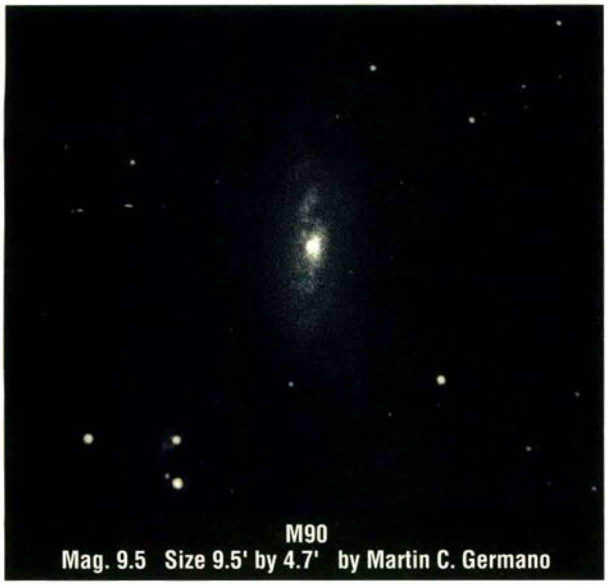
M61
NGC 4765
NGC 4688
NGC 4496
NGC 4412



M61
Mag. 9.7 Size 6.0' by 5.5' by Jack Newton

M89
Mag. 9.8 Size 4.2' by 4.2' by Martin C. Germano



M90
Mag. 9.5 Size 9.5' by 4.7' by Martin C. Germano

Bright Galaxies in Virgo

Object	R.A.(2000.0)	Dec.	Mag.	Size
NGC 4216	12h15.9m	+13°09'	10.0	8.3' by 2.2'
M61	12h21.9m	+ 4°28'	9.7	6.0' by 5.5'
NGC 4324	12h23.1m	+ 5°15'	12.6_B	2.5' by 1.2'
M84	12h25.1m	+12°53'	9.3	5.0' by 4.4'
M86	12h26.2m	+12°57'	13.0_B	7.4' by 5.5'
NGC 4402	12h26.1m	+13°07'	11.7	4.1' by 1.3'
NGC 4413	12h26.5m	+12°37'	13.0_B	2.5' by 1.7'
NGC 4425	12h27.2m	+12°44'	11.9	3.4' by 1.2'
NGC 4435	12h27.7m	+13°05'	10.9	3.0' by 1.9'
NGC 4438	12h27.8m	+13°01'	10.1	9.3' by 3.9'
M49	12h29.8m	+ 8°00'	8.4	8.9' by 7.4'
M87	12h30.8m	+12°24'	8.6	7.2' by 6.8'
NGC 4526	12h34.0m	+ 7°42'	9.6	7.2' by 2.3'
M89	12h35.7m	+12°33'	9.8	4.2' by 4.2'
NGC 4567	12h36.5m	+11°15'	11.3	3.0' by 2.1'
NGC 4568	12h36.6m	+11°14'	10.8	4.6' by 2.1'
M90	12h36.8m	+13°10'	9.5	9.5' by 4.7'
M58	12h37.7m	+11°49'	9.8	5.4' by 4.4'
M59	12h42.0m	+11°39'	9.8	5.1' by 3.4'
NGC 4638	12h42.8m	+11°26'	11.3	2.8' by 1.6'
M60	12h43.7m	+11°33'	8.8	7.2' by 6.2'
NGC 4647	12h43.5m	+11°35'	11.4	3.0' by 2.5'

Object: Designation in Messier or NGC catalog. **R.A. and Dec.:** Right ascension and declination in equinox 2000.0. **Mag.:** V magnitude of galaxy; subscript B denotes blue magnitude. **Size:** Diameter in arcminutes.

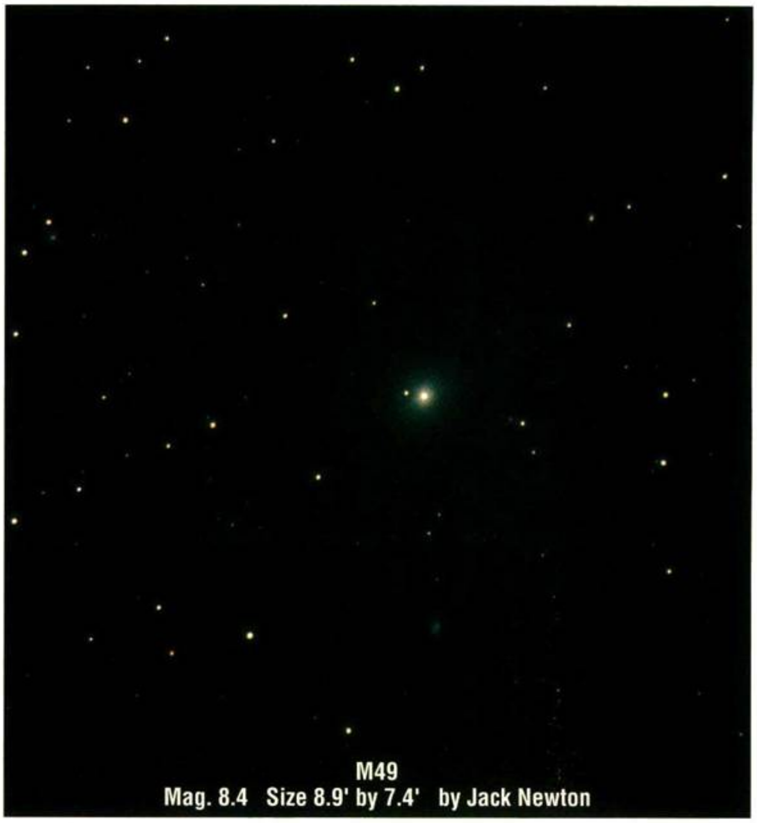
the best is **M61** (NGC 4303). This galaxy is a "transitional" barred spiral with characteristics of both a normal and a barred spiral. In a small telescope, this outlying member of the Coma-Virgo cluster is a pale oval measuring about 5' across. A moderate instrument under very good skies will reveal a bright nucleus and mottled patches of light from the unresolved spiral arms. In a 12-inch scope the hint of spiral structure becomes more apparent.

About 45' north of M61 lies a challenging galaxy for small telescope users. **NGC 4324** glows at 12.5 magnitude. This small, oval-shaped Sa-type spiral lies near the double star 17 Virginis. The star is somewhat distracting and makes the feeble glow of the galaxy hard to spot. A 6-inch or larger scope is normally required to spot this pretty galaxy.

M84, M86, NGC 4402, NGC 4435 and NGC 4438 create an interesting visual panorama. Between these five galaxies, all located in the same low-power field, we can see the combined light of at least a trillion stars! In addition, two much fainter edge-on spiral galaxies lie in the same field. **M84** is a type E1 elliptical galaxy. Photographically, it appears slightly oval. Visually, however, it appears virtually circular — especially in small instruments. M84 is strikingly bright: In large telescopes it shows no detail other than a bright nuclear region and a soft halo of light trailing off into the darkness. **M86** is slightly fainter than M84 and slightly more oval in shape. It is classified as an E2 elliptical galaxy. Some observers have noticed that the outer edges of M86 are fuzzier — less well defined — than those of M84. Compare the two in your telescope

Core of the Virgo Cluster
Photo by Kim Zussman

M87
Mag. 8.6 Size 7.2' by 6.8' by Jack Newton



M49
Mag. 8.4 Size 8.9' by 7.4' by Jack Newton

— do you see any difference? About 10' north of M86 is a faint edge-on spiral (type Sb), **NGC 4402**. This spindle-shaped galaxy has a low surface brightness. In smaller scopes, the elongated appearance is less evident, with the nuclear region being the most pronounced. In larger instruments, the fainter disk formed by the outer portion of the arms is visible. The equatorial lane requires a very large instrument to be seen.

South and slightly east of M86 lies **NGC 4413**, an SBb-type barred spiral. It has a low surface brightness, making it a difficult object for small telescopes. In moderate apertures, this galaxy forms a compact circular patch. Northeast lies **NGC 4425**, a faint SB0 type lenticular galaxy. It is fainter than NGC 4413, but is nonetheless visible in a 6-incher under very good skies. NGC 4425 appears as an oval haze with a bright nucleus.

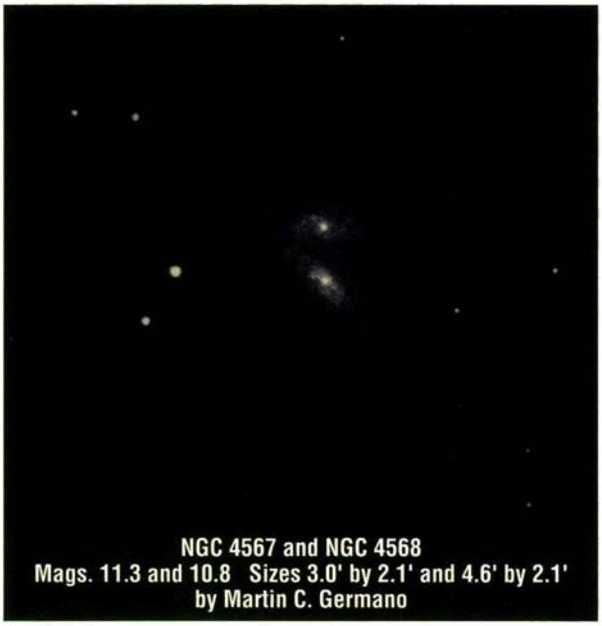
NGC 4435 and **NGC 4438** form an unusual interacting pair. With small to moderate scopes, these galaxies appear as ovals. NGC 4435 and NGC 4438 are larger than they appear visually. NGC 4435, the northern member of this celestial "Siamese twin," is a lenticular galaxy of class SB0. The outer halo has a lower surface brightness than a comparable elliptical galaxy. NGC 4438 is a distorted, dusty spiral galaxy and is highly inclined to our line of sight. Consequently, you'll need a large scope to see detail in this pair of colliding galaxies. NGC 4438 has a lower surface brightness than NGC 4435 — perhaps from all of the dust — making it appear slightly fainter.

At magnitude 8.6, **M49** (NGC 4472) is another bright elliptical galaxy. Classed as an E4, this galaxy is more elongated in appearance than the other bright ellipticals save M59. Twelve-inch-or-larger telescopes bring out a bright nuclear region, but overall this galaxy brightens evenly from the center until fading sharply into the night sky. Smyth described this galaxy in 1844 as "a bright, round, and well-defined nebula; the nebula has a very pearly aspect." Another elliptical, **M87** (NGC 4486), is similar in appearance to M86 but is somewhat brighter. Classified as a type E0 peculiar elliptical, M87 appears as a round glow with a bright center. This galaxy, a strong radio and x-ray emitter known as Virgo A, has a small eruptive jet emanating from its nucleus.

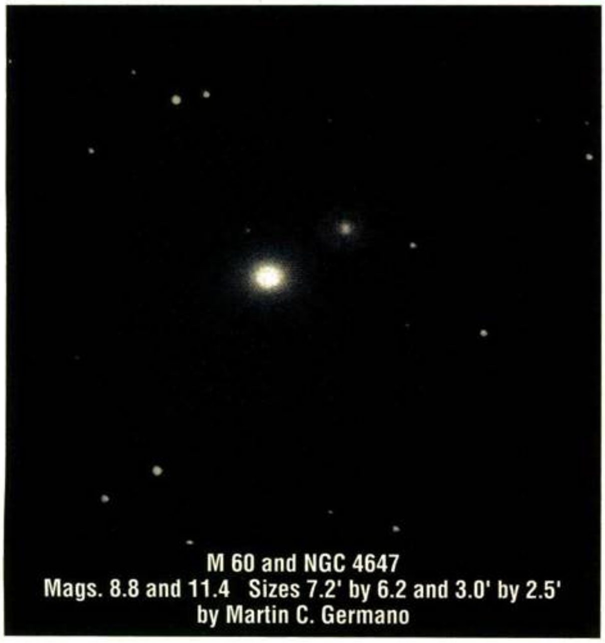
At magnitude 10.9, **NGC 4526** is a bright galaxy of the S0/Sa type. This is a borderline galaxy, sharing characteristics of both lenticular (S0) galaxies and the Sa type, with a large central hub and small ill-defined outer arms. Some sources class this galaxy as an elliptical, but it is definitely a lenticular object. NGC 4526 is large and very oval in shape. With large scopes, it appears soft and milky. The poorly developed arms cannot be seen visually. A true elliptical, **M89** (NGC 4552), is classified as a type E0. It is reminiscent of M87, which lies a little more than a degree west but M89 is a little smaller and fainter. Some references call M89 a type E1, which would make it slightly elongated.

M90 (NGC 4569) is similar to and very slightly brighter than M61. It is considerably more elongated because it is more highly inclined to our line of sight. Located about a half-degree north and slightly east of M89, this spiral (type Sb) is an easy target in the smallest telescope or good binoculars. With small and moderate instruments, the inner portion of the hub of the galaxy is visible. The core is slightly brighter than the inner arms, and the outer arms have a much lower surface brightness. The nuclear region is distinct in 8-inch and larger scopes. The fine, delicate nature of M90's spiral arms make them difficult to observe. An uneven light in the hub is due to the

M 58
Mag. 9.8 Size 5.4' by 4.4' by Rick Dilsizian



NGC 4567 and NGC 4568
Mags. 11.3 and 10.8 Sizes 3.0' by 2.1' and 4.6' by 2.1'
by Martin C. Germano



M 60 and NGC 4647
Mags. 8.8 and 11.4 Sizes 7.2' by 6.2 and 3.0' by 2.5'
by Martin C. Germano

large patches of dark nebulosity located there.

NGC 4567 and **NGC 4568** form an unusual pair of interacting spiral galaxies. As if they are physically connected, astronomers have named this system the Siamese Twins. Unlike their namesake, these distorted Sc type galaxies are not permanently attached, but are only cartwheeling past each other. In tens of millions of years, their passage will be complete. As they hurtle apart, they will probably be connected by an umbilical cord of stars, dust and gas for millions of years. In small telescopes this pair may seem to be a single, odd-shaped galaxy.

M58 (NGC 4579) is a bright spiral galaxy, equal in brightness to the giant M87. Like M90, this galaxy is a type Sb object. Its orientation is less inclined and the central hub is well exposed. The spiral arms, as is typical for Virgo galaxies, have a low surface brightness. Consequently, they are difficult to detect in small instruments and difficult to resolve in large ones. Photographs show a foreground star superimposed on one of the filamentary spiral arms. Can you see it? A 7th-magnitude star lies about 7' west of the galaxy. Place it out of the field of view to obtain the best view of M58.
M59 (NGC 4621) is a bright, compact glow about 1' east of M58. At 9.6 magnitude, it is readily visible in small instruments, even under light-polluted skies. M59 is an elongated elliptical galaxy of type E5. There are several other galaxies in the immediate area. **NGC 4638**, a 12.2 magnitude elliptical galaxy, lies to the southeast, forming a triangle with M60.

M60 (NGC 4649) is another large elliptical galaxy and, like M84, is classified as a type E1. M60 is one of the brightest in Virgo. In a small telescope, it appears as a roundish glow, brightening toward the center. Careful scrutiny with small instruments will reveal a second galaxy, **NGC 4647**. This galaxy is a spiral (type Sc) with a low surface brightness. It is often missed by observers looking at the well-known M60. The nuclear region of NGC 4647 is more condensed and is the easiest part to see with a small telescope.

The concentration of galaxies packed into Virgo provides backyard astronomers with plenty of fun galaxy searching. Instead of checking off one galaxy after another in a systematic fashion, consider some options. One project you may want to try is to examine the bright elliptical galaxies. Look at their classification type. Do they visually match what you consider the "proper" classification?

Scan the bright galaxies to determine which appear the brightest and how they vary in shape. You might be pleasantly surprised to see that the galaxies do not look like copies of each other. When you observe spirals, which have the lowest surface brightnesses? The central hubs of most are easy to see. But how many spiral galaxies reveal the soft outer glow from the arms? If you have a large instrument, especially 16-inches or larger, how many galaxies show resolved spiral arms? If you observe with a pair of binoculars or a good finderscope, how far beyond Messier's double handfull can *you* go? □

Alan Goldstein is the founder of the National Deep Sky Observers Society, a contributing editor of Deep Sky *magazine, and coauthor of the book* Deep Sky Observing with Small Telescopes *(Enslow, 1989).*

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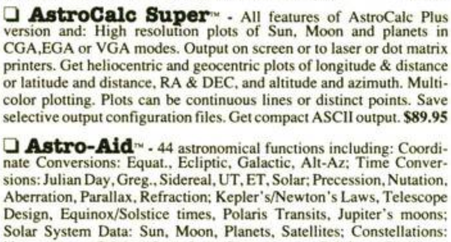

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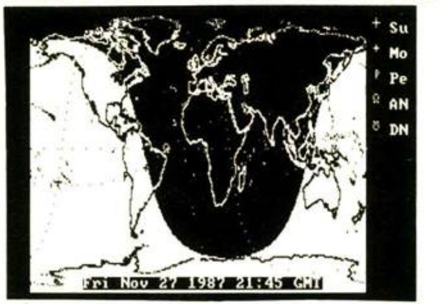

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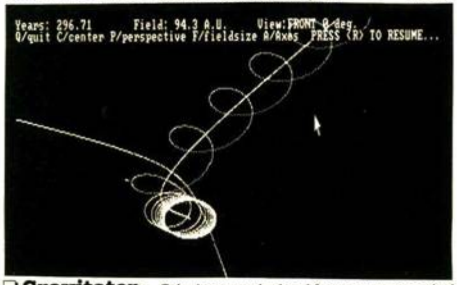

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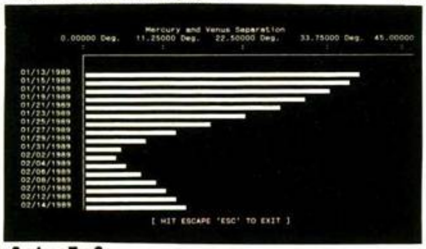

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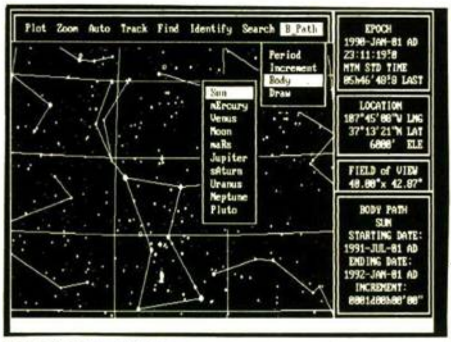

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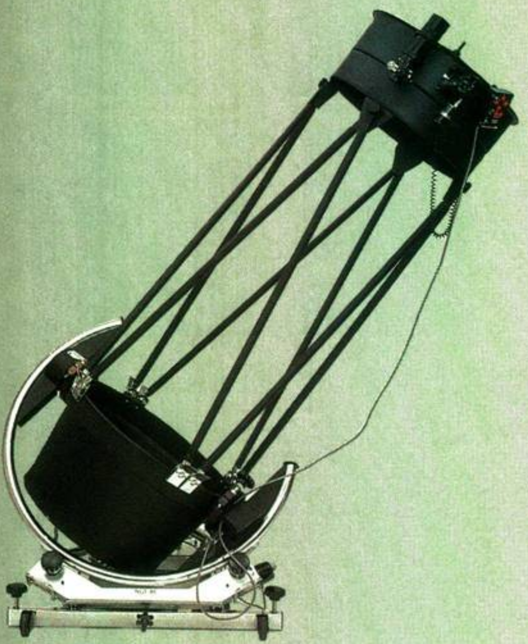
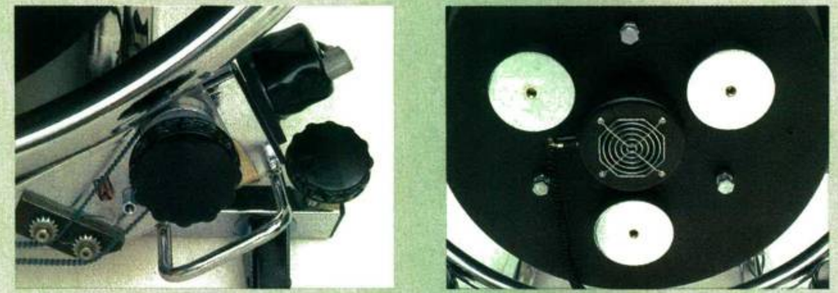
PRODUCT REVIEW

THE New Generation Telescope



The NGT successfully combines large aperture with an equatorial mount in a portable telescope.

by Alan Dyer



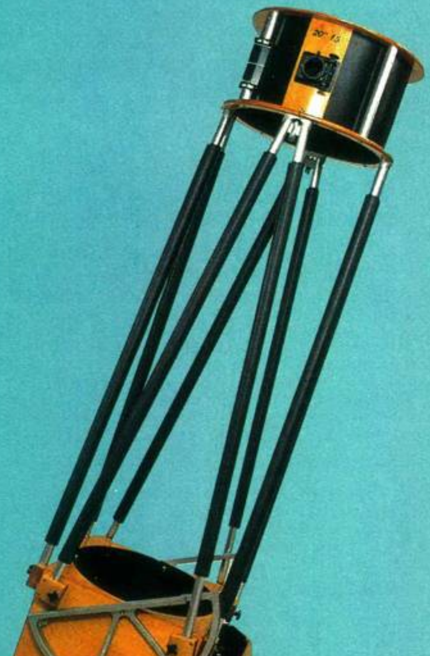
THE NGT'S DRIVE (left) uses a DC motor that turns a roller that the large polar ring rides on. A belt drives another roller on the other side of the mount. The mirror housing (right) has a central cooling fan, three counterweights, and three collimation bolts.

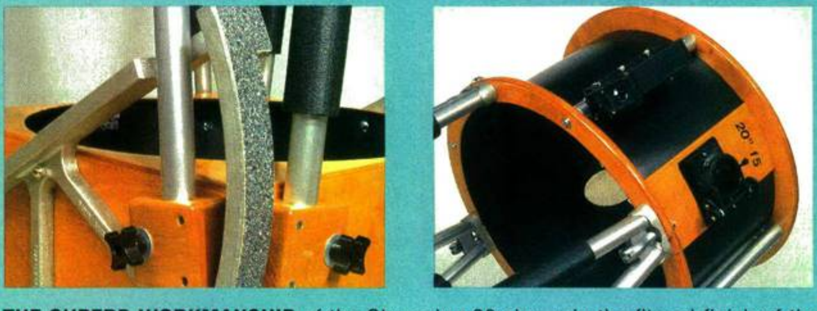
PRODUCT REVIEW

THE Obsession 20

The Obsession telescopes elevate the Dobsonian to a new level of quality and ease of use.

by Alan Dyer





THE SUPERB WORKMANSHIP of the Obsession 20 shows in the fit and finish of the rocker and mirror box components (left) and in the lightweight but rigid upper end (right). Note the low-profile focuser and Telrad finder.

Most backyard astronomers aren't long in the hobby before they begin to lust after large aperture. Big telescopes give bright views. They show familiar objects with photographic clarity and reveal faint objects beyond the grasp of lowlier telescopes.

In the 1980s telescope builders broke previous aperture barriers by designing Newtonian reflectors in simple, easy-to-build mounts. These "Dobsonians," named for the original designer, John Dobson, provided big scopes at low prices. Amateurs were in aperture heaven. But Dobsonians forced telescope users to sacrifice the one thing always considered essential to a "serious" telescope — an equatorial mount. Dobsonians cannot automatically track the stars. Dobsonians can't be used to take astrophotos. Many amateurs would say, "So what? I'm just interested in looking." But as the '80s drew to a close, an increasing number of amateur observers found themselves wanting big aperture *and* tracking capability. And they wanted it in a package they could transport to dark sky sites.

In response to the increasing demands of a sophisticated amateur community, Jim Burr, founder of Jim's Mobile Industries, designed what he has dubbed the New Generation Telescope. "I wasn't interested in building another Dobsonian," Burr told us. "It's not my nature to build what everybody else is building. I want to build something that stands out in the marketplace." The NGT certainly does that.

The NGT-18

Manufacturer: Jim's Mobile Industries, 1960 County Road 23, Evergreen, Colorado 80439; (303) 277-0304.
List Prices: 18-inch: $8,900 with Digital Setting Circles (NGC miniMAX $150 extra; NGC-MAX $350 extra; 16-inch: $7,400; 25-inch: $22,500. Shipping and crating extra.
Pros: Compact; one-person setup; excellent optics; smooth motions; accurate drive; ideal for deep-sky photography.
Cons: Polar alignment difficult; assembly awkward; truss poles shaky; baffling insufficient .

Assembling an NGT

The NGT-18 has an 18-inch f/4.5 Galaxy Optics mirror housed in a type of equatorial mounting unfamiliar to most backyard astronomers. The "split ring" mount incorporated into the NGT has long been a standard design for professional observatory telescopes and has been used by some amateur telescope makers. The design features a large horseshoe-shaped ring that forms the bearing surface for the right ascension motion. In the NGT, this surface is a metal ring 36 inches across, a size that ensures a very stable yet smooth-turning axis. The split-ring mount also has a much lower center of gravity, and is therefore more compact, than traditional fork and German equatorial designs.

The bottom unit of the NGT contains the split-ring mount, the

---

I stepped back and the thought hit me. "Hey, I just set up a 20-inch telescope! By myself!" Yes, there it was, eight feet tall and with enough aperture to tackle any target in the visible universe. And on my first night out, it took me about 15 minutes to set up the Obsession. The next night it took me half the time. I was impressed.

The Obsession 20 is one of a new breed of high-quality Dobsonian telescopes that are changing the thinking of a lot of amateurs these days. (See "The New Generation of Dobsonians" in the April 1989 ASTRONOMY.) The design that Obsession Telescope's owner Dave Kriege adopted for his line of scopes is one of the finest we've seen for maximizing compactness in a giant-aperture scope.

An Obsession with Detail

Not only is the design ingenious, but Kriege's commercial implementation of it is an example of craftsmanship we've rarely seen in any telescope, let alone a "light-bucket" Dobsonian. The woodworking is superb and solid: the craftsmen Kriege contracts to build his telescopes use 13- and 15-ply Russian Baltic birch for the rocker and mirror boxes. All joints and edges are rounded, and all surfaces are richly stained and coated with ultraviolet-resistant lacquer.

The large altitude bearings are cast aluminum with a bearing surface of Ebony Star laminate, a textured Formica. The mirror cell uses a combination of an edge sling and an 18-point flotation system mounted in a framework of welded steel. The Obsession 20 uses a 2-inch-thick f/5 mirror. Both it and the secondary mirror are made by Galaxy Optics of Buena Vista, Colorado.

The featherweight tube poles are aluminum covered with a spongy foam (nice in cold weather!). The upper end weighs only ten pounds; it is a wood and aluminum framework with a cylindrical wall of thin black plastic. Kriege uses a spider and secondary mirror holder made by Kenneth F. Novak & Co. of Ladysmith, Wisconsin.

The focuser is a low-profile unit made by AstroSystems of Longmont, Colorado. It is a Crayford-style design that uses a roller to move the focuser tube instead of a rack and pinion gear. The low-profile design offers only one inch of travel but allows Kriege to keep the secondary mirror as small as possible — in the 20-inch scope the secondary is only

The Obsession 20

Manufacturer: Obsession Telescopes, 923 Stoney Road, Lake Mills, WI 53551; (414) 648-2328.
List Prices: 20-inch: $4,495 plus $95 for Light Shroud; 25-inch: $8,895 plus $125 for Light Shroud. Shipping and crating extra.
Pros: Easy setup requiring no tools; excellent optics; smooth motions; superb fit and finish.
Cons: Susceptible to wind; wide, heavy bottom unit; tight inside diameter of focuser tube; no front baffle tube.

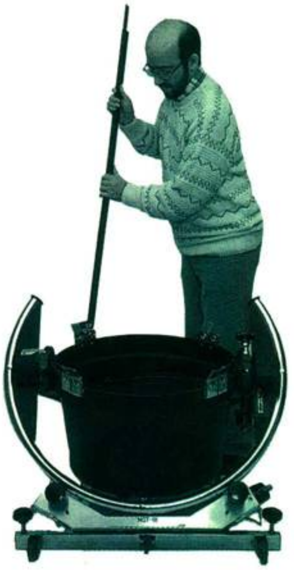
drive, and the "tub" that holds the mirror and cell. The cell is an ingenious design that uses an 18-point flotation system that does not have potentially distorting edge clips; instead the back surface of the mirror is glued onto eighteen metal cups. Side handles on the cell allow you to carry the mirror-and-cell combination as a single component.

The assembled bottom unit weighs 163 pounds. This is a hefty piece of equipment. For transportation, the upper end unit nestles into the mirror tub, requiring a storage space for the packed-up telescope of 36 (width) by 30 (depth) by 32 inches (height).

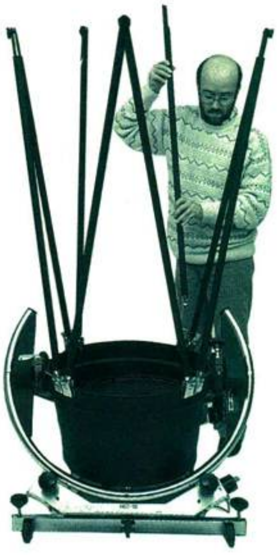
To lighten the load, you can remove the 58-pound mirror (still attached to its cell) from the tub. The mount can be broken down still further by pulling the 60-pound tub and split ring assembly off the 45-pound steel base. This base has a rocker assembly for tilting the mount to various latitudes. The normal range is from 30° to 55°, but custom versions are available for other latitudes. Disassembled in this fashion (see the photo on page 82), each of the pieces is light enough for one person to carry, though not without some effort. A set of optional rubber wheels is available to aid in moving the telescope.

The eight 47-inch poles that form the tube snap into ball-and-socket connectors around the rim of the tub. The cylindrical top end that contains

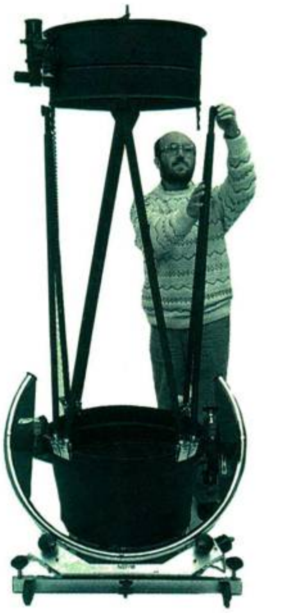
Assembling an NGT



STEP 1: Insert poles into sockets



STEP 2: Pair the poles together



STEP 3: Bolt the upper end onto poles

3.1 inches across the minor axis. This obstructs 15% of the aperture (by diameter), minimizing loss of contrast and light due to the central obstruction while still providing sufficient illumination off-axis for a non-photographic scope.

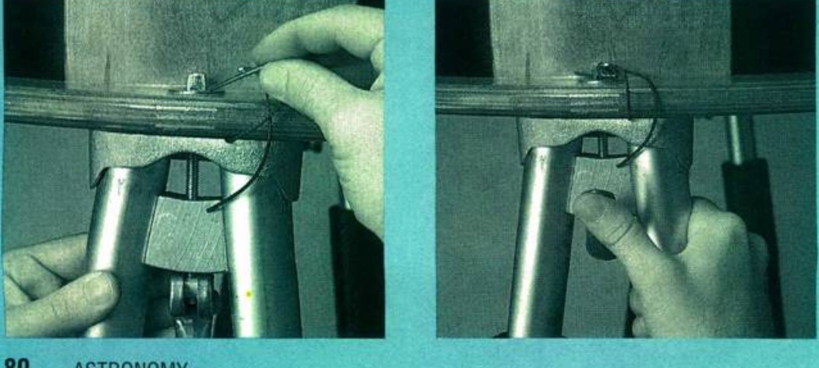
The Obsession scopes come with a Telrad finder, but no other finder scope or any eyepieces. Nice additional touches are the 12-volt fan built into the tailgate for cooling the mirror and a 12-volt heater rope for the secondary mirror cell to keep dew off the secondary. However, only bare wires extend from these electrical devices; you are left to supply power and a switching system.

Obsession telescopes come at a price. The Obsession 20 sells for $4,495, a price tag most of us thought we'd never see for an altazimuth telescope. However, this *is* a 20-inch telescope, a size most of us once thought we'd never see in an amateur telescope, especially one this portable.

Assembling an Obsession

The rocker and mirror box together (with mirror in place) weigh 150 pounds. While it's possible to remove the mirror to lighten the load, the cell is not designed for easy removal and replacement of the mirror. To transport the massive bottom unit, you instead attach large *wheelbarrow handles* to the rocker box. (These come with the scope.) Once the handles were in place, I

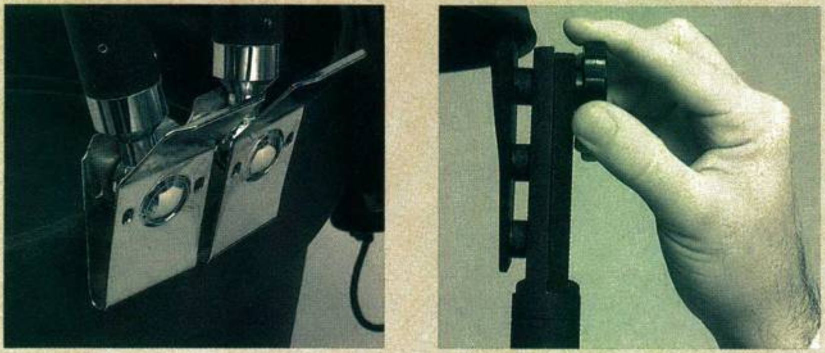
TO ATTACH THE TOP OF THE OBSESSION you slip a wedge between the poles and insert a captive bolt through the rim of the upper end and a hitch pin through the bolt (left). You then flip a lever (right) to clamp the poles to the top section of the telescope.



the secondary mirror, focuser, and 8x50 finder scope bolts onto the paired tube poles. My first cautious attempt at assembling the NGT took about 20 minutes, but subsequent setups took half that time, remarkable for a telescope of this size. Unless you are very short, the entire assembly can be done without a ladder, a welcome feature.

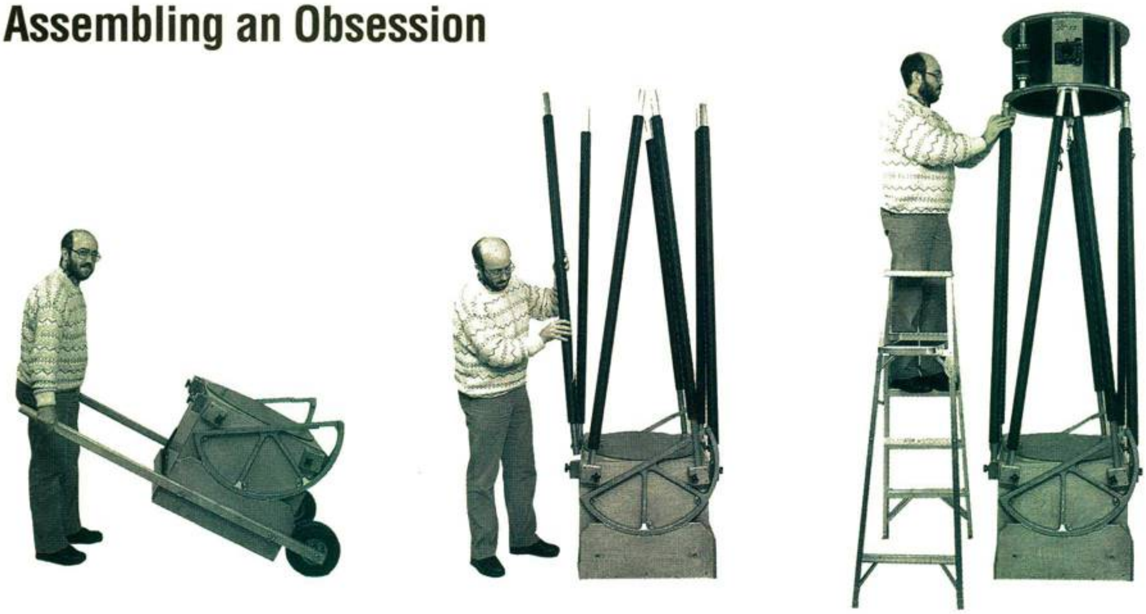
The principal frustration I encountered was that the pairs of poles tend to flop down easily. This can create a juggling act as you hold the 11-pound upper end in mid-air, grab the sprawling poles, and try to attach them. The NGT needs a better method of keeping the poles paired together and a means of attaching them to the bottom tub that holds them firmly positioned on the vertical.

The adjustment for the latitude setting is a knob located on the steel base. I found that before the tub and mirror were installed this adjustment was relatively easy, but once the weight of the whole scope was resting on the rocker base, I could not turn the latitude knob. To do a final polar alignment, I had to use the leveling screws on the four corners of the base to adjust the height of the mount. To adjust the polar alignment in the east-west direction I had to nudge the whole scope from side to side. Considering that the big benefit of the NGT is its excellent equatorial mount, I found the inconvenience of precise polar alignment (and the lack of any instructions for



TO ASSEMBLE AN NGT you push each of the eight truss poles into a spring clip (left), then attach the poles in pairs to the upper unit. You can select one of three bolt positions (right) to vary the focal plane position for visual use or for photography.

Assembling an Obsession



STEP 1: Wheel the bottom unit into place **STEP 2: Insert the eight tube poles** **STEP 3: Clamp the upper end to the poles**

found it easy to wheel the assembly anywhere by myself, even over rough ground and up small slopes. However, the main drawback is that if you must lift the heavy bottom unit (say, in and out of a vehicle or down steps) you'll need two people. Using ramps, you could wheel the bottom unit into and out of a van or wagon, but this is very difficult with any vehicle with a very high tailgate such as a four-wheel-drive truck. (Believe me, I tried it!)

The bottom unit is 30 inches square and will just squeeze through a standard outside doorway (but not a door on an RV). With the wheelbarrow handles in place the width becomes 34.5 inches. The height of the bottom unit at its tallest point is 31 inches; the unit just tucks under the canopy of a small pickup truck.

Each of the poles is 70 inches long. The upper end of the scope, called the Upper Tube Assembly (or UTA) comes in a cylindrical "hatbox" 27 inches across and 16 inches tall. This hatbox fits between the wheelbarrow handles when they're attached to the rocker box. You'll need a cargo area at least 6-feet long and 3-feet wide to transport an Obsession 20.

Once you have the bottom unit placed on the ground, the rest of the assembly is relatively easy. The eight poles clamp inside split-wood blocks. Once inserted they do not sway or flop around. For the next step polar alignment in the manual) a deficiency.

Using an NGT

Once you have it set up, the NGT is a pleasure to use. The maximum height of the eyepiece at the zenith is a convenient 78 inches, extremely low for such a large telescope. For most of the sky, no ladder at all is required to reach the eyepiece. For added convenience, the top half of the upper unit rotates to place the eyepiece at a comfortable position. The rotation motion was not as velvety smooth as I would have liked, but it worked fine and maintained collimation no matter where I placed the eyepiece.

While the NGT doesn't balance with extra-heavy eyepieces (unless you attach some optional counterweights on the poles), you can place enough friction on both axes to stop the scope from falling when it's out of balance. The axes are still loose enough, however, to allow you to move the scope from target to target. The motions were smooth and without slop or jerkiness. Once you are on target you can lock both axes if you wish.

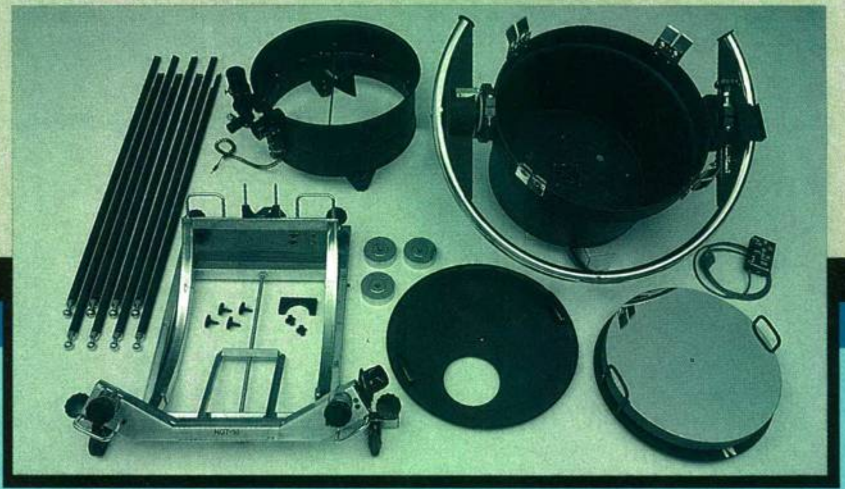
However, while I felt that the mount itself was very solid, the all-metal scope still exhibited an inordinate amount of shake. After a good rap near the eyepiece, the vibration took 4 to 5 seconds to completely die out; plus the vibrations damped out gradually. The main source of the resonance seemed to be the spring clips that hold the bottom ends of the poles.

The DC motors on the right ascension and declination axes are powered by two 6-volt gel cells that are built into the base. Built-in batteries are wonderful! I found that after the recommended overnight charge, the batteries powered the scope for about ten hours. As an alternative, the scope can be powered from a car battery.

The NGT comes with a control paddle that allows you to guide the scope for photography in right ascension and declination using a 2x speed override or to slew the scope with a 4x speed. However, I feel that a 4x speed is still too slow for scanning and slewing. An 8x or 16x override is far better, especially on a big scope like the NGT where it is impractical to have manual slow motions.

The NGT does not come with setting circles. Instead, the 18-inch model is supplied with Jim's Mobile DSC digital circles. There *is* an indica-

THE NGT'S COMPONENTS consist of (clockwise starting at lower right): the mirror in its cell, the mirror cover with off-axis mask, three mirror cell counterweights, the rocker base with latitude adjustment, eight truss poles, the upper end unit, the split ring mount and mirror tub, and the hand controller.



you need a ladder. After carefully carrying the UTA up the ladder, you place its four metal seats on top of the four pairs of pole tips. Dangling from the UTA are four wedge and bolt assemblies. You slide the metal wedge between the poles, insert the bolt through a hole in the rim of the UTA, then slip a hitch pin through the bolt. You throw a lever and click! — the UTA is clamped to the poles. You repeat this for each pair of poles and the Obsession is ready to use. All with no tools.

Your immediate thought is that surely the optics won't be collimated. I tested this suspicion and found that each night I assembled the telescope the optical collimation was bang on. This was true no matter which orientation I placed the UTA in. If you do need to collimate, there are large knobs on the mirror cell (easy to turn with gloves on) for adjusting the primary. Again, no need for tools — excellent!

Not shown in our illustrations is the final step — pulling a black shroud over the tube assembly. This shroud is made of ripstop nylon and fastens using a drawstring at the top and bungee cords at the bottom. It is a $95 option for the 20-inch model and I highly recommend it. Without such a covering, stray light can scatter across the field, reducing contrast.

Observing with an Obsession

As easy as the Obsession is to set up and use, it is still a big telescope. Reaching the Telrad finder and the eyepiece requires a 5-foot ladder. Spending most of your observing time perched on a ladder, even only two or three steps above the ground, can be fun for quick glimpses at star parties but can be uncomfortable for extended observing on your own. (For the record, the height of the eyepiece with the scope aimed at a 60° altitude is about 88 inches; with the scope pointed straight up the eyepiece height is 95 inches.)

Nevertheless, if big-aperture views are what you're after, this scope will deliver. The Galaxy Optics mirrors proved to be superb. Stars were pinpoints and the extra-focal images were nearly identical on either side of focus with no sign of astigmatism and no obvious spherical aberration or zonal errors. As expected, the f/5 optics suffered from very little edge-of-field coma. On several nights of good seeing the Obsession provided stunning views of Mars, proving the telescope's value as more than just a light-bucket. On our scale of "A" (great) to "E" (junk) I'd give the optics in our test scope an A–. In addition, the mirror collimation did not shift as the scope was moved around the sky.

However, a caveat: poor seeing will play havoc with the images far more often with a large scope than with a smaller scope. Also, the massive primary mirror can take several hours to cool down to the ambient temperature. While the design of the Obsession allows for good air flow around the mirror, on nights with rapidly falling temperatures or turbulent air, the star and planet images will always look fuzzy. This is a tor and scribe mark on one declination axis to mark 90° to aid in polar alignment, a nice touch. Also standard on the NGT-18 is a variable speed motorized focus (the accessory that made Jim's Mobile famous). Once tightened properly it had little backlash or "deadband" but did jar the focuser drawtube when it reversed direction, causing a slight image shift.

The collimation adjustments on the primary mirror require a wrench. Again, I would prefer to see the instruction manual provide detailed collimation instructions, as well as a set of collimation tools supplied as standard equipment. I did find that after reassembly from a complete breakdown (including removal of the mirror/cell unit from the tub), the scope was out of collimation, requiring 10 to 15 minutes of tweaking of the primary mirror to set it right.

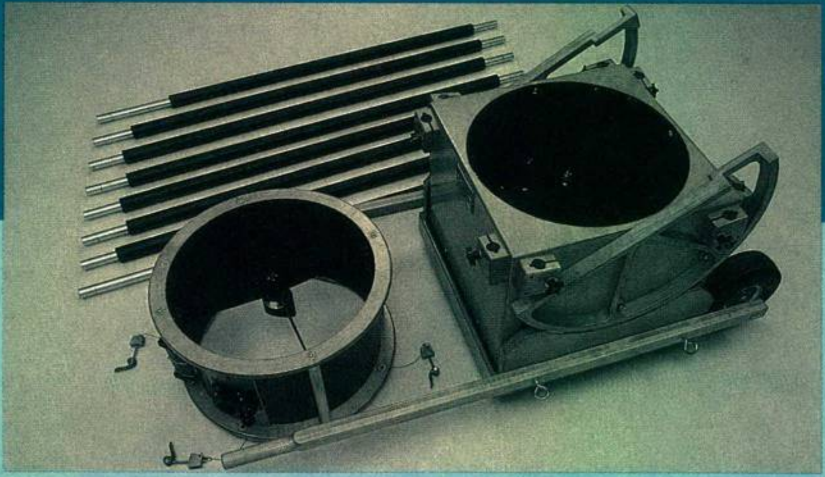
Another surprising deficiency was the lack of a fabric cover or "light shroud" for the tube, an essential item for keeping stray light out of any open tube telescope. Stray light can also enter directly into the eyepiece from the opposite side of the tube, lowering image contrast and fogging long-exposure photos. Burr told us a shroud and tube extension baffle will be offered soon to correct these problems.

Now, the bottom line: what are the optics like? In a star test, I found the optics to be excellent. Out-of-focus star images were nearly identical on either side of focus, with no trace of astigmatism and no obvious spherical aberration or zonal errors. On our scale of A (excellent) to E (junk), the NGT's Galaxy Optics mirrors rate an A–. This is a telescope that will provide superb images of all subjects. The generous size of the secondary mirror (a 4.5-inch minor axis) is optimized for 35mm astrophotography. It provides a fully illuminated one-inch diameter field. Vignetting and coma would be visible, however, in photos taken with medium format cameras.

For any prime focus deep-sky photography, you'll have to use an off-axis guider since the open framework of the NGT does not lend itself to the attachment of guidescopes or even piggybacked lenses or Schmidt cameras. But if fabulous prime focus shots are what you want, the NGT should do the job.

In fact, one enthusiastic NGT owner and astrophotographer, Dave Young, wrote to tell us that his NGT-18 "was the best toy I've ever bought. My last few photo sessions have almost been religious experiences." Well, we can't promise that an NGT will change *your* life, but if you are looking for a transportable telescope with aperture and tracking capability, the NGT is an excellent choice. While it still has some rough edges to iron out, the NGT is the best equatorially mounted telescope we've seen in the big aperture league.

PS: If the NGT-18 is a bit rich for you, Jim's Mobile offers an NGT-16. It uses exactly the same mounting and tube hardware as the 18-inch model (so it is no smaller or lighter) but uses a 16-inch f/5 Galaxy Optics mirror. The NGT-16 sells for $7,400. They also offer a 25-inch for $22,500. □



THE OBSESSION'S COMPONENTS consist of the massive rocker and mirror box (shown with wheelbarrow handles attached), the upper tube assembly (at left, shown without its hatbox container), and eight 70-inch-long truss poles. These components will fit into a large wagon, pickup truck, minivan, or multi-purpose vehicle.

high-performance scope that needs ideal conditions to work at its best.

Mechanically, the scope works beautifully. The motions are smooth with no backlash or jerkiness. I found it easy to track objects even at high power and easy to move the scope when it was aimed at the zenith.

If there is a flaw in the Obsession it's that the motions are a little too easy. Although the telescope is designed to balance with heavy eyepieces, with a 2-pound 20mm Nagler and the scope aimed below 45°, the scope slips downward with the slightest touch. On a night with gusty winds (a common occurrence at remote dark sky sites), the scope becomes unusable. The wind swings the scope around like a weathervane. Kriege suggested to us that you can increase the friction of the motions by removing the wax he places on the Formica bearings.

The focuser on our unit also had too small an inside diameter. All the 2-inch eyepieces I tried did slide in, but some were a very tight fit. Tugging at a balky eyepiece would move the scope off position.

Some eyepieces I tried (a 35mm Ultrascopic Plössl, a 16mm Orion Megavista, and a 50mm Takahashi) would not reach focus because the focuser would not slide in far enough. The Obsession is normally set up for TeleVue Naglers and Wide-Fields; indeed a 40mm TeleVue Wide-Field just reached focus. Kriege suggests that should your eyepieces not focus, you can extend the focal point farther by trimming the truss poles with a pipe cutter.

Other improvements I feel would be useful would be a detachable light baffle extending off the front end. The secondary mirror is close to the top edge of the tube and stray light can hit the secondary as well as enter directly into the eyepiece. Also, the secondary mirror needs a cover to protect it during assembly. Some kind of scratch-resistant material would also be nice around the points where the wheelbarrow handles bolt to the rocker box. However, these are all minor oversights in an otherwise superb design.

As Kriege remarked to us, "My philosophy behind these telescopes is that they should be a joy to use. They're designed for people who want to have fun exploring the universe." I think he has succeeded admirably.

PS: If a 20-inch scope isn't big enough for you, Kriege also offers a 25-inch — for $8,895. □

THE JOY OF MOONGAZING

Even a modest-sized telescope can show the Moon in all its beauty.

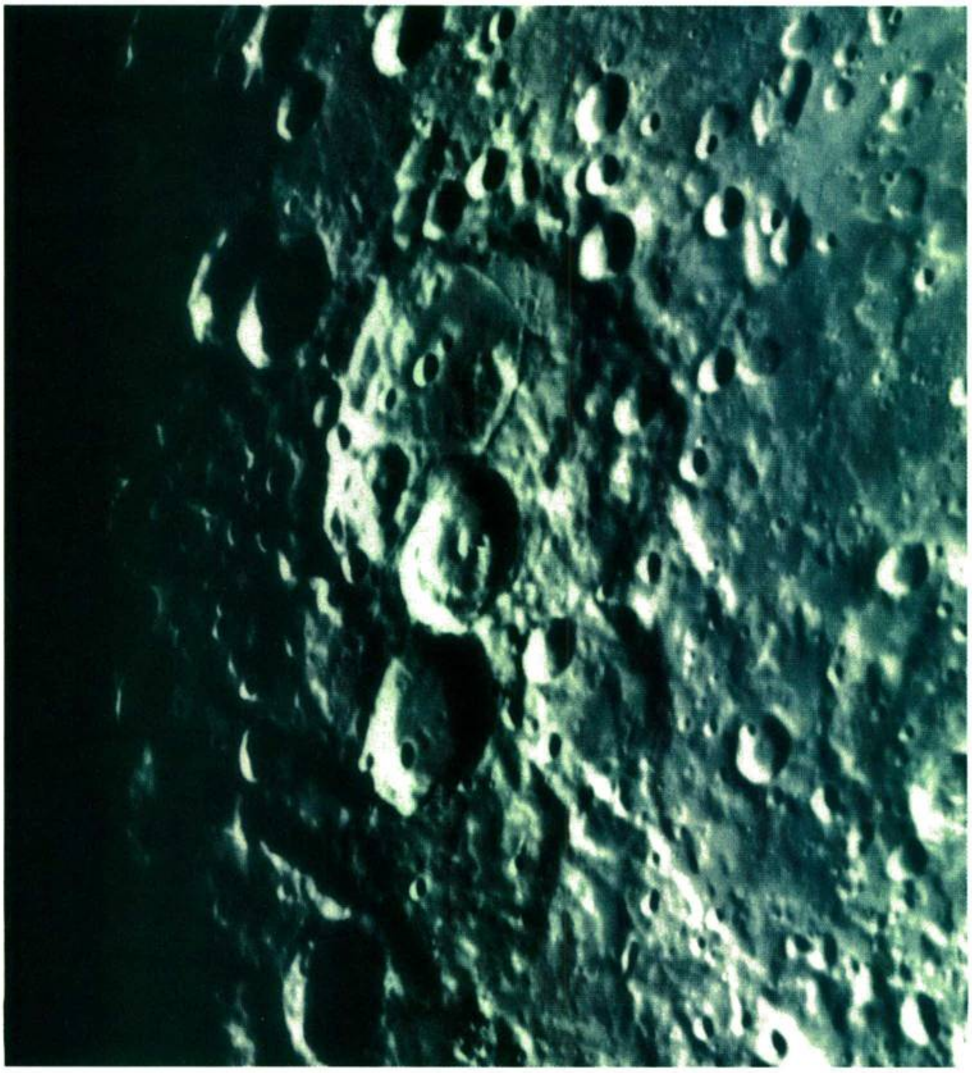
Photographs by Gérard Therin

Its light a cold, silvery gleam in a late winter sky, the March Moon is highly tempting for every backyard astronomer. Full on the last day of February, the Moon is New on March 16 and Full again on March 30. For the first half of March, therefore, the Moon will be a late-night object, rising after sundown and remaining visible into dawn. The "dark of the Moon" intervenes midmonth, a time when the Moon will rise and set essentially with the Sun. Then, beginning as a thin sliver in the twilit west after sunset, the Moon returns to view in the evening sky as March warms into April.

While big telescopes make hunting the faint galaxies of springtime easier, no one needs a light bucket to observe the Moon. Indeed, all the photos with this story were taken using an 8-inch Schmidt-Cassegrain telescope on Technical Pan film. French amateur Gérard Therin used eyepiece projection to magnify the image (giving f/ratios of f/60 to f/70) and exposures of 1.3 seconds during moments of excellent seeing.

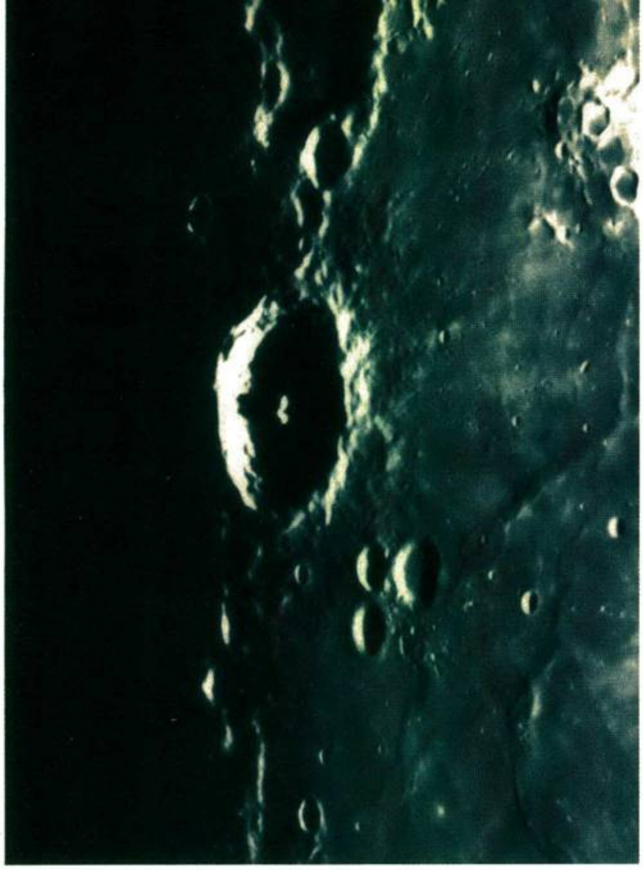
To follow the night-by-night march of the terminator, the line between lunar day and night, is for many telescope owners a highly satisfying activity. And it includes supremely dramatic events — for example, if you have not yet seen sunrise or sunset over Copernicus, you have an enormous thrill in store.

But even apart from such "show-stoppers," the Moon offers tremendous sights every month. After Full, the shadows of lunar

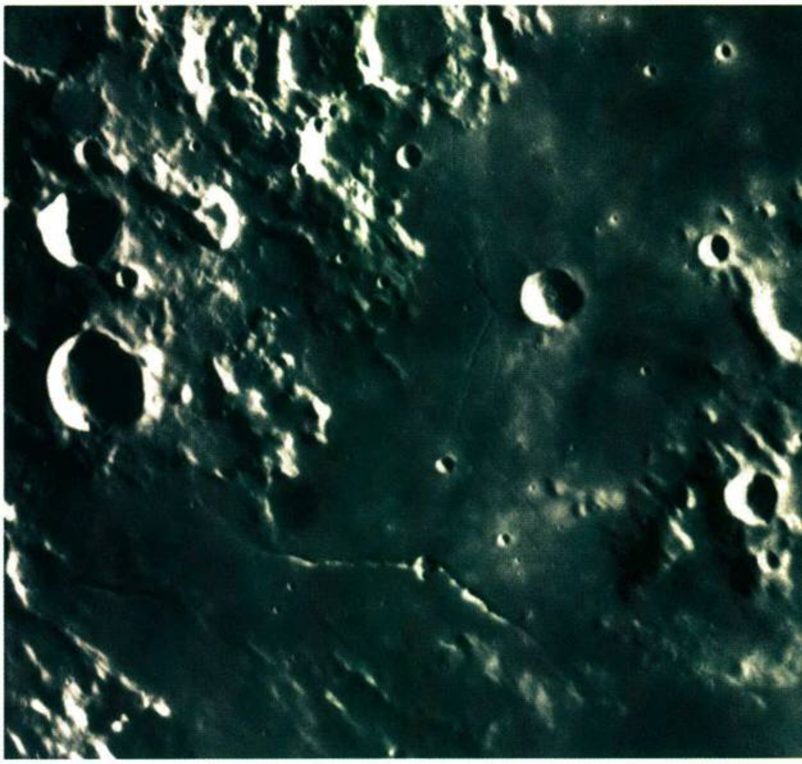


RUINED BUT STILL distinct, the 120-mile-diameter crater Janssen has a complex, uneven floor with rilles in its southern part. The big crater inside the rim is Fabricius; the one outside is Metius.

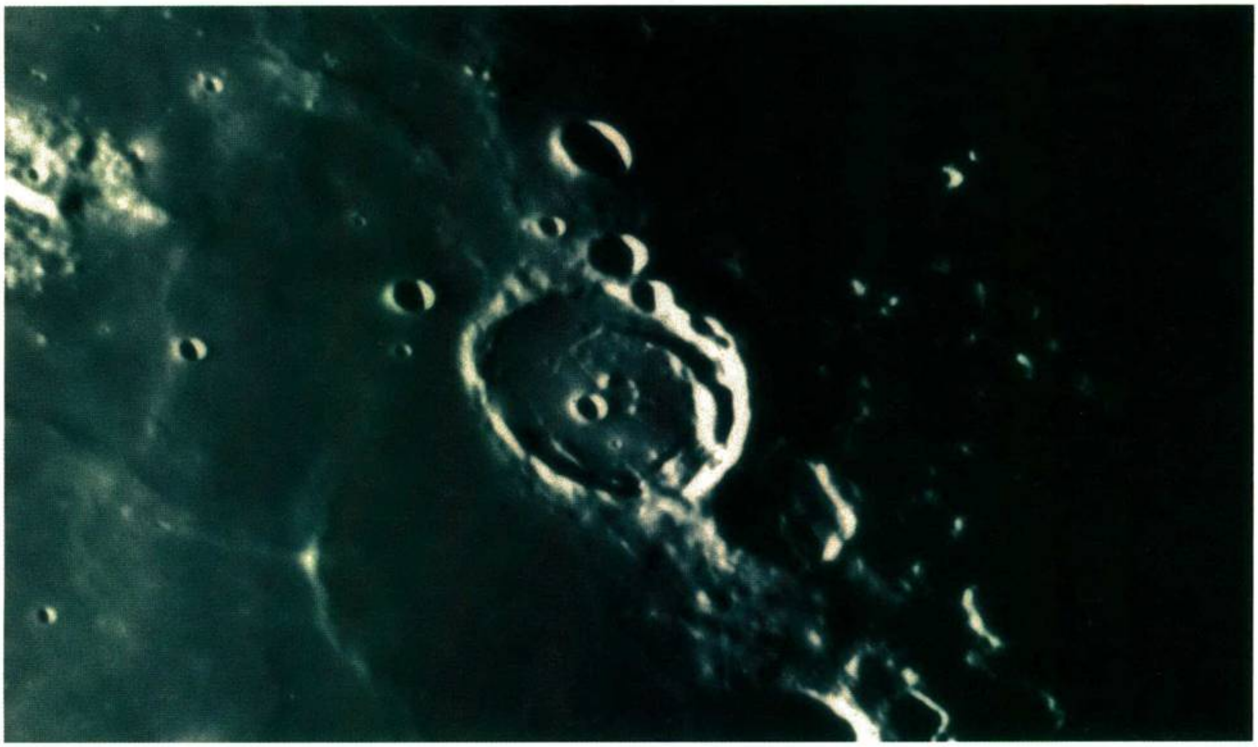
A TRIO OF 60-MILE CRATERS — Theophilus, Cyrillus, and Catharina — march up the western shore of Mare Nectaris, while the Altai Scarp, a broken remnant of the Nectaris impact basin, curves down the right side of the photo.



SUNSET OVER LANGRENUS highlights secondary impact craters, faint rays, and details in the apron of debris outside the wall.

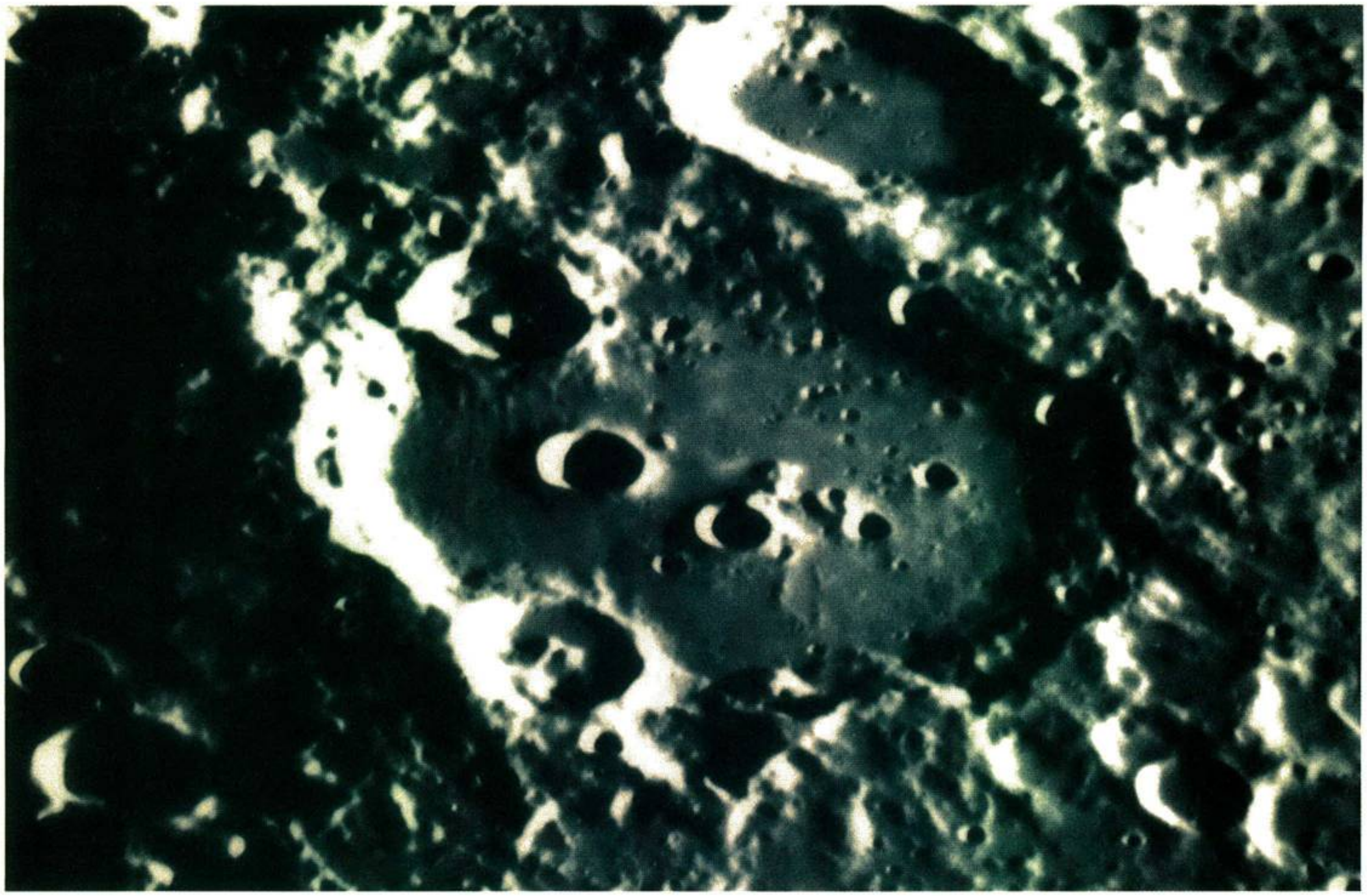


PUNCTUATED BY VOLCANIC CRATERLETS, the linear Hyginus rille (bottom) makes a distinct contrast to the shallow, but more numerous, Triesnecker rilles (top).

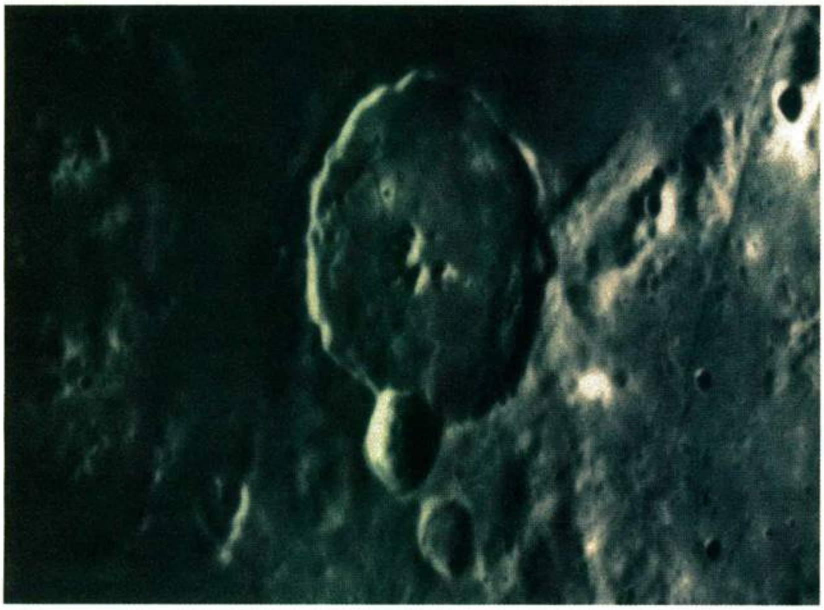


FLOODED GHOST CRATERS and variously hued lava flows mark Mare Nectaris, a flooded impact basin. Note the craterlets and hummocky deposits of ejecta next to Theophilus (lower right corner).

PARTLY DESTROYED but with several interior peaks and rilles, the 60-mile crater Posidonius stands on the northeastern shore of Mare Serenitatis.



MONARCH OF THE MOON'S Southern Highlands, 140-mile Clavius has a convex floor peppered with craterlets, debris, and perhaps the remains of a central peak.



A MAGNIFICENT RUIN on the shore of Mare Humorum, the flooded interior of Gassendi is cracked by a multitude of rilles.

DECEPTIVELY SMOOTH except near sunrise and sunset, the floor of Ptolemaeus (bottom) embodies many "ghost features" smothered by lava.

afternoon gather on the eastern limb, and craters and mountains lose their chalky blandness. Topography develops as inky shadows grow and merge.

It's fun to watch the changes in a single feature such as Langrenus (page 87) or Ptolemaeus (opposite), especially the latter. As the Sun lowers over Ptolemaeus, its floor transforms remarkably. Most of the time, it appears flat and all but featureless. Yet when the Sun's elevation nears the horizontal, many ghost craters begin to appear on the crater's floor. How many can you pick out? Normally, these are hidden by the flat lighting that comes with high Sun angles. But for a few hours each month — just after sunrise and just before sunset — Ptolemaeus hints at a rich and varied history almost eradicated by lava flows.

Novice or old hand, if you haven't had a look at the Moon lately, there's no better time than this spring.

— *Robert Burnham* □

New Astronomy Products

1 New Telescopes from Orion

The SpaceProbe 4.5's 114mm diameter mirror gathers 3.6 times more light than 60mm telescopes and twice as much light as 80mm models. The aluminized and overcoated mirror has a focal length of 900mm. The SpaceProbe comes with an equatorial mount with slow-motion controls and two 0.965-inch diameter eyepieces — a 9mm Kellner for 100x and a 25mm Kellner for 36x. The 6x30 right-angle finder scope attaches by means of a double bracket, six-screw mounting ring.

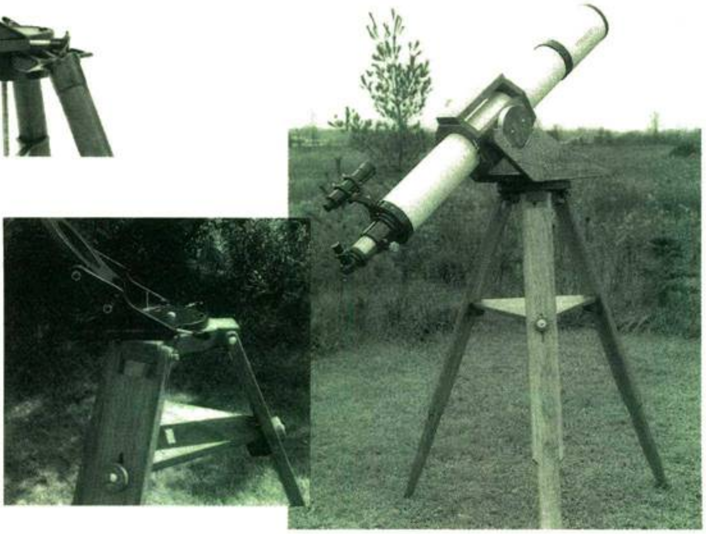
The UltraScan 80 wide-field refractor features an 80mm two-element air-spaced lens that uses high-performance ED glass. The lens is also multi-coated. The telescope can be used from 12.5x for wide-field observing to 150x for high-power viewing. The rack and pinion focuser has a 2-inch diameter chrome-plated brass drawtube that can be used with the standard 1.25-inch eyepiece holder or an optional 2-inch eyepiece holder or threaded camera adapter. The UltraScan 80 includes a 6x30 finder scope and a ¼-20 tripod mounting block.

Orion Telescope Center, 2450 17th Avenue, Santa Cruz, CA 95062; (408) 464-0446. SpaceProbe 4.5 Reflector: $339; UltraScan 80 Refractor: $449.

2 Celestron Powerstar PEC

The Powerstar 8 now features Celestron's Periodic Error Correction (PEC) circuitry. The Powerstar has f/10 Schmidt-Cassegrain optics with Starbright™ coatings, a cordless DC servo quartz drive system with PEC, a swing-through fork mount with slow-motion controls, and a 7.54-inch Byers worm gear drive. Standard accessories include hand controller, 6x30 finder scope, 30mm Plössl eyepiece for 68x, prism star diagonal, wedge with latitude adjuster, and newly designed metal tripod with rubber covered legs. The Powerstar is powered by a 9V alkaline battery (included).

Celestron International, 2835 Columbia Street, P.O. Box 3578, Torrance, CA 90503; (800) 421-1526 or (213) 328-9560 (8 a.m. to 4 p.m. Pacific Time). $2,998.



3 Hand-Crafted Wood Tripods and Mounts

Carlino Woodcraft's telescope tripods are made of solid black cherry finished with WATCO Danish oil. Each tripod has a 1¾-inch thick hardwood top plate to aid in damping vibration. The top plate can be adapted to accommodate virtually any type of mount. (Mounting holes are pre-drilled for Celestron and Meade wedges.) Each leg is 5 inches wide and 1⅛ inches thick on standard models and 1¾ inches thick on heavy duty models. The shelf bolts to the tripod legs, bracing the tripod and providing a generous table surface. Tripods in black walnut are also available. A matching Dobsonian mount suitable for 5- to 7-inch refractors is also offered. It features Teflon bearings in altitude and azimuth.

Carlino Woodcraft, 7118 Kinne Road, Lockport, NY 14094; (716) 433-3432 (6:30 to 9:00 p.m. Eastern Time). Dobsonian mount with 60-inch tripod: $950 (black walnut version: $1,125); Tripods alone: $329 to $529 depending on leg height and thickness. Shipping is extra.

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

4 UltraScan Eyepieces

Orion Telescope's UltraScan eyepieces offer a 77° apparent field of view. All eyepiece housings are black anodized and internally blackened to reduce stray light, and feature rubber fingergrips for comfort and cold-weather use. The 1.25-inch diameter models are a 5-element design with high-refractive index glass. All air-to-glass surfaces are multi-coated. They are available in focal lengths of 9mm, 12mm, 15mm, and 19mm. A 30mm focal length model is available in a 2-inch diameter barrel. The lowest power UltraScan is a 40mm focal length model. It is a 7-element multi-coated eyepiece in a 2-inch barrel and has an apparent field of 68°.

Orion Telescope Center, 2450 17th Avenue, Santa Cruz, CA 95062; (408) 464-0446. $99 to $139.

5 StarScape CCD Cameras

A line of ultra-low light level cameras is now available from First Magnitude Corporation. The StarScape IIC features a thermoelectrically cooled CCD with a 14-bit A/D converter. It is available with a 590x490 pixel monochrome or 250x250 pixel color CCD. The StarScape IIA and IIB are thermoelectrically and liquid-nitrogen cooled cameras. Both use a 16-bit A/D converter and are available with 590x490 pixel CCDs, with a 1024x1024 CCD as an option.

First Magnitude Corporation, 519 S. 5th Street, Laramie, WY 82070; (307) 745-3744. Model IIA: $13,900; Model IIB: $12,900; Model IIC: $9,500. Prices include software. An automated filter wheel/photometer is also available for $3,500.

6 Fingermit Glove

Ideal for cold weather use when both comfort and manual dexterity are essential, Fingermit features hinged flip-over caps that permit selected exposure of any or all fingers or the thumb. Fingermit is made of knitted 100-percent wool with a Thinsulate®-lined mitten cap. Pairs are available in Small (sizes 5 to 8) and Large (sizes 9 to 12), and come in navy blue, gray, black, beige, and camouflage.

Tempo Glove Manufacturing, Inc., 3820 W. Wisconsin Avenue, Milwaukee, WI 53208; (800) 558-8520 (in Wisconsin call (414) 344-1100); FAX: (414) 344-4084. $26.95 per pair plus shipping and handling. ☐

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Edmund Scientific
AstroScan

Orion® SpaceProbe™ 4.5" Equatorial Reflector

NEW!

Our new 4.5" f/8 reflector gathers 3.6 times more light than 60mm telescopes; twice as much as 80mm models; ideal for deep space observation. Full featured equatorial mount with slow motion controls & setting circles. Achromatic 6x30 right angle finder and two eyepieces: 25mm (36x) and 9mm (100x). Deluxe hardwood tripod and accessory tray. Compare our price!

#9097 **$399** (18.73)

Orion® TeleVista™ 60mm Altazimuth Refractor

This affordable telescope is equally at home viewing the rings of Saturn or boats across the bay. One of our most popular sellers, it will provide you with years of viewing enjoyment. Includes a quality coated 2-element achromatic objective lens and two quality Kellner .965" eyepieces, 25mm & 9mm, for sharp, clear images at 28x and 78x. Sturdy all metal optical tube and yoke mount, plus strong adjustable wooden tripod, smooth focuser and diagonal prism. A great, economical choice for observers of all ages.

Best Buy! #9091 **$169** (9.90)

Orion® Sky Explorer™ 60 Equatorial Refractor

The Sky Explorer's sturdy equatorial mounting is designed specifically for astronomy; it's ideal for lunar and planetary study, while providing good views of nebulas, star clusters, and double stars. By day, it's a powerful terrestrial telescope, great for nature study and scanning distant vistas. It features a 900mm focal length, MgF_2 coated objective lens; 6x30 achromatic crosshair finderscope; rack-and-pinion focuser, fully coated right-angle star diagonal prism; two quality fully coated Kellner eyepieces, 25mm (36x) and 9mm (100x); all metal equatorial mounting; worm gear slow-motion control knobs, celestial coordinate setting circles; dual flexible control cables; adjustable counterweight; adjustable deluxe hardwood tripod; and lighted accessory tray.

#9092 **$329** (12.70)

Orion® 7x50 Observer™ Binoculars

NEW!

Our new Observer binocular is an ideal moderately priced night-vision binocular for both astronomy and general purpose daytime observation. Fully coated optics with a 7° field of view, and a bright 7mm exit pupil. Rugged ribbed rubber covering for a good grip.

#9620 **$84.95** (3.66)

Orion® Sky Explorer™ Mini Deep Sky 8x56 Binoculars

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view.

#9504 **$139** (4.19)

Celestron 7x50 Pro

An ideal 'night glass,' also excellent for twilight or daytime viewing. Lightweight construction provides comfortable hand-held viewing over extended periods. Fully Multi-Coated BAK-4 optics. Tripod adaptable, water resistant, easy-grip textured covering. Case, extra wide neck strap, and lens caps included. 7.1° field of view, bright 7mm exit pupil. Weight 28 oz.

#9588 **$159** (3.19)

Orion® Little Giant™ 9x63 Roof Prism Binoculars

Popular mid-sized binocular, Fully Multi-Coated and remarkably light weight. Excellent contrast and sharpness at center of field, with enough power to see lunar craters & Jupiter's moons. 5.5° field of view. Weight 2.8 lbs.

#9500 **$199** (4.80)

Superior Performance 7x50 Adlerblick Binoculars

Incredible wide field eyepiece design, Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the archrival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps, straps.

#9612 **$269** (4.16)

Orion® 10x70 Enhanced Giant Binoculars

Big binocular performance in a lightweight package you can hand-hold for hours. Ideal for sweeping the dust lanes of the Milky Way. Fully Multi-Coated, BAK-4 Prisms. Fantastic!

#9501 **$279** (5.87)

Orion® Enhanced™ Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest-field available. Ideal for deep-space observation under dark skies. Hand-holdable.

#9502 **$349** (6.43)

16x80 MC-45% higher power, excellent for astronomy and daytime observation. Tripod recommended.

#9496 **$379** (6.43)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required.

#9498 **$389** (6.43)

SuperGiant™ 14x100 Binoculars

NEW!

The ultimate long-distance terrestrial or high-power astronomical binocular. Gigantic 100mm (almost 4 inch!) lenses gather 156% of the light of 80mm binoculars. They feature Fully Multi-Coated optics and BAK-4 prisms. Comes with the integral platform mounting plate for a secure, stable attachment to any standard photographic-type tripod. (Definitely required for binoculars of this size.) Individual eyepiece focus improves alignment and allows for more precise focus. 14x magnification, field of view 3.3°, exit pupil 7.0mm, weight 7.5 lbs., height 13.5".

#9495 **$799** (12.95)

Orion® Big Eye 8x50 & 11x80 Finder Scopes

NEW!

Ideal for upgrading any telescope including Schmidt-Cassegrains. Available non-illuminated or with wireless, adjustable, battery-operated illuminated reticle and Polaris grid for accurate polar alignment. With 90° diagonal prisms. Optional deluxe dual-ring brackets are perfect for 8" and 10" Celestron or Meade; will fit many others, too.

8x50 Models

The 50mm objectives gather 2.7 times more light than 30mm finders!

8x50 Standard Finder #7100 **$89.95** (3.31)
8x50 Illuminated Finder #7135 **$134.95** (3.56)
Bracket— For 8" & 10" #5143 **$25.95** (1.89)

11x80 Models

These huge finders gulp in over 7 times the light of 30mm finders; 2.5 times more than 50mm models! You might spend more time viewing through the finder than through your main telescope!

11x80 Standard Finder #7146 **$219** (4.16)
11x80 Illuminated Finder #7143 **$269** (4.16)
Bracket— For 8" & 10" #5140 **$37.95** (2.39)

Folding Porta Chair

NEW!

Surprisingly comfortable considering it's small size; this chair is ideal for astrophotographers or those who find observing while standing to be uncomfortable. An ideal addition to any amateur astromomer's observing equipment. Weighs 6 lbs. and is just 22" long folded up. Opened up, the seat height is 1 1/2' and it is 10 1/2" x 11 1/2" in size.

#5938 **$49.95** (3.60)

Deluxe Eyepiece Case

Organize and protect your valuable eyepieces and other accessories. This durable case with double hinges holds up to 10 eyepieces plus barlow. Die cut foam insert for snug secure fit. O.D. 8-1/2"x12-1/2"x3-1/8".

#5913 **$17.95** (2.49)

Deluxe Metal-Clad Accessory Cases

Keep accessories and camera safe and clean. Diced foam inserts can be tailored to your needs. Sturdy handle, two latches, key.

Regular Case: 16"x12"x6 1/2" #5920 **$49.95** (5.09)
Large Case: 19 1/2"x12"x6 1/2" #5921 **$69.95** (5.92)

Deluxe Field Tripod Tote Bag

Designed for the field tripod with padded insert to separate wedge from tripod during transportation. Specifically made for wedge combinations of Schmidt-Cassegrain telescopes up to 10" aperture. Allows storage without changing polar alignment. This blue bag is made of tear, rip and mildew resistant 100% Cordura nylon.

#15096 **$79.95** (4.65)

Orion® VariPower™ 2-3x Multi-Coated Barlow Lens

Our best barlow offers significant improvement over other models we've seen. The magnification is adjusted by sliding the internal lens cell along a calibrated scale (you don't have to poke a finger or pencil inside to do this). Fully Multi-Coated optics provide excellent sharpness, contrast and brightness. 1.25" diameter.

#8748 **$69.95** (2.59)

Orion® 3-element Fully Multi-Coated Barlow Lens

Fully Multi-Coated 3-Element Barlow lens provides superior imaging with precise color correction at three wavelengths. For maximum light transmission and highest contrast, we have used the finest quality multi-coating on each air to glass surface. 1.25" diameter.

#8750 **$59.95** (2.59)

Orion® Deluxe Fully-Baffled Multi-Coated Barlow Lens

Fully internally opaqued and baffled to block stray light for noticeably higher contrast. Large 27mm multi-coated 2-element lens provides 2x magnification with any 1.25" eyepiece.

#8746 **$49.95** (2.39)

100% Satisfaction
Money-Back Guarantee
If you are not completely satisfied with your purchase from Orion, for any reason, just return it in new condition within 30 days after delivery for a full refund.

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High Resolution Orion® Ultrascopic Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7- element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Compare with other brands selling for much more!

Wide Field 5-element

35mm #8560 **$89.95** (2.59)

30mm #8562 **$79.95** (2.59)

25mm #8564 **$64.95** (2.59)

Medium-High Power 5-element 20mm #8566, 15mm #8568, 10mm #8570, 7.5mm #8572

$59.95 ea. (2.59)

High-Power 7-element 5mm #8574, 3.8mm #8576

$79.95 ea. (2.59)

Orion® MegaVista™ 1.25" Wide Angle Eyepieces

Incredible Fully Multi-Coated high-transmission 7-element eyepieces with integral rubber eyeguard and long eye-relief.

10.5mm- An incredible 67° field for outstanding planetary or deep space performance.

#8552 **$109** (2.79)

16.8mm- Outstanding high-contrast eyepiece with stunning 70° field ideal for deep space.

#8554 **$119** (2.79)

Orion® UltraZoom™ 7-21mm 1.25" Eyepiece

The finest zoom you can buy for your 1.25" telescope. An excellent choice for astronomy or terrestrial observing. 65°-35° field.

#8556 **$129** (2.79)

Orion® Explorer Series 1.25" Eyepieces

Remarkably affordable, Multi-Coated parfocal eyepieces with great performance. Each carefully selected series has been chosen to provide a sensible progression of magnifications. Threaded for filters. Internally blackened to prevent stray light reflections.

Kellner Eyepieces-
6mm #8536, 9mm #8538, 12mm #8540,
18mm #8508, 25mm #8510, 40mm #8512

$33.95 ea. (2.19)

Orthoscopic Eyepieces- 5mm #8500, 7mm #8502, 9mm #8504, 12.5mm #8506, 18mm #8524, 25mm #8526

$46.95 ea. (2.19)

Orion® Explorer Series .965" Eyepieces

Get the most from your small telescope with these fine Multi-Coated eyepieces. Standard .965" barrels fit all Japanese standard small telescopes.

.965" Orthoscopic Eyepieces-
5mm #8580, 7mm #8581
9mm #8582, 12.5mm #8583

$37.95 ea. (2.19)

.965" Kellner Eyepieces
18mm #8584, 25mm #8585
.965" Achromatic Huygenian Eyepieces- 40mm #8586

$24.95 ea. (2.11)

World's Finest Illuminated Reticle Eyepiece

6mm Orthoscopic design for required high-power guiding, plus unique X-Y adjustable reticle positioning for easy guide-star alignment. Wireless LED illuminator has adjustable brightness.

#8487 **$139** (2.79)

Orion® 9mm Orthoscopic Illuminated Reticle Eyepiece

9mm Orthoscopic eyepiece with wireless adjustable brightness illuminator. Bull's-eye within three concentric circles helps measure limits of acceptable guiding error.

#8488 **$119** (2.79)

Orion® 12mm Kellner Illuminated Reticle Eyepiece

12mm Kellner eyepiece with cable plugs into LX/3, LX/5 and Premier drive bases, and most drive correctors with illuminated reticle output for polar alignment and guiding.

#8482 **$69.95** (2.59)

77° Field UltraScan Wide-Angle Eyepieces

NEW!

Unlimited visibility is yours with up to 77 degrees of field to catch your eye. High quality optical materials and superb coatings, for the ultimate in contrast and resolution.

1.25" UltraScan Eyepieces
Five optical elements utilizing the latest high refractive-index optical glass materials achieve extremely wide fields with fewer elements than many competitive eyepieces, reducing weight and cost. Each lens surface is fully Multi-Coated, for the ultimate in contrast and elimination of stray reflections. Integral rubber eyeguards.

9mm-#8420 **$99** (2.79), ***12mm***-#8421 **$109** (2.79)

15mm-#8422 **$129** (2.79), ***19mm***-#8423 **$139** (2.79)

2" UltraScan Eyepieces
These incredible oculars provide breathtaking panoramic, bright views that will astonish you!

30mm 2" UltraScan Eyepiece - This 5-element, 77 degree field UltraScan eyepiece combines the widest possible apparent and true fields with a larger image scale than our 40mm.

#8424 **$199** (2.79)

40mm 2" UltraScan Eyepiece - Orion's brightest, widest true-field UltraScan eyepiece utilizes a sophisticated 7-element design, providing a 68 degree apparent field; the widest we could fit into the 2" diameter barrel.

#8425 **$179** (2.79)

Orion® SkyGlow™ Enhanced Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters- Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter-fits 1.25" eyepieces.

#5660 **$59.95** (2.59)

Schmidt-Cassegrain Broadband Filter- fits rear cell of Meade & Celestron SC scopes.

#5658 **$79.95** (2.59)

52mm Broadband Filter- fits all camera T-rings.

#5668 **$66.50** (2.59)

SkyGlow UltraBlock Filters- Visual Only
For severely light polluted areas.

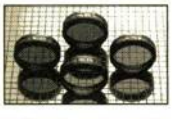
1.25" UltraBlock Filter- fits 1.25" eyepieces.

#5654 **$79.50** (2.59)

Schmidt-Cassegrain UltraBlock Filter- fits rear cell of Meade & Celestron SC scopes.

#5656 **$99.00** (2.59)

Orion® Color Filters for Eyepieces



Solar system observations are dramatically improved by Orion colored filters. For visual use, thread one into the barrel of any standard eyepiece. For planetary and lunar photography, Schmidt-Cassegrain owners can attach the filter to the eyepiece inside the tele-extender. Can also be threaded directly into a universal camera adapter.

Basic Set of 4 Filters .965"- Includes #80A Blue, #58 Green, #25 Red, #15 Yellow.

#5510 **$29.95** (2.19)

Basic Set of 4 Filters 1.25"- Includes #80A Blue, #58 Green, #25 Red, #15 Yellow.

#5514 **$39.95** (2.19)

Expansion Set of 4 Filters 1.25"- Includes #21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.

#5516 **$39.95** (2.19)

Deluxe Set of 8 Filters 1.25"- Includes all the filters in our basic and expansion filter sets.

#5517 **$74.95** (2.79)

Individual 1.25" Filters- #80A Blue (#11040), #58 Green (#5540), #25 Red (#5536), #15 Yellow (#5532), #21 Orange (#5534), #47 Violet (#5538), #11 Light Yellow-Green (#5530), #82A Very Pale Blue (#5544)

$11.95 ea. (.99)

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664 **$14.95** (2.11)

1.25" #5662 **$14.95** (2.11)

Popular Observer's Chairs

Make observing more comfortable and enjoyable with one of these great chairs.

Standard Model-
Has adjustable-height center column and padded vinyl seat. Folds for easy storage.

#5935 **$39.95** (3.96)

Deluxe Model-
Is much heavier-duty, built for professional musicians. Extra thick padding, wide footprint. Adjustable and disassembles for storage.

#5934 **$89.95** (5.65)

Breakthrough Low-Price Plössl Eyepieces!

NEW!

These new Multi-Coated Plössl eyepieces are incredibly low priced! Good quality optics for sharp, clear images. Precision four-element Plössl lens elements mounted in sturdy aluminum barrels. Available in 12mm, 18mm, or 25mm focal lengths, with 1.25" barrels. Buy all three for less than some single eyepieces!
12mm-#8596
18mm-#8597
25mm-#8598

$39.95 ea. (2.39)

Orion FlexiShield™ Dew Caps

NEW!

Eliminate dew problems with FlexiShield! Better performance, more rugged, and easier storage than rigid dew caps. Made of durable, unbreakable, fire-retardant Kydex™. Form into a tube with the velcro closure, or change into a flat rectangle or small-diameter tube for easy storage and transportation. No paint to chip or scratch off. They fit your telescope tube snugly, thanks to the wide rubber padding and full-length velcro closure. Nothing needs to be attached to your telescope; needs no screws, no tape, no glue. Once in place, they are very rigid and do not block the optical path. Models to fit most telescopes.

90mm Celestron/Meade Spotting Scopes	#4203	**$24.95** (2.39)
90mm Celestron Rubber Armored Spotting Scopes	#4205	**$24.95** (2.39)
4" Meade Schmidt-Cassegrain	#4204	**$24.95** (2.39)
8" Celestron/Meade Schmidt Cassegrains	#4200	**$39.95** (2.39)
10" Meade Schmidt Cassegrains	#4201	**$49.95** (2.39)
11" Celestron Schmidt Cassegrains	#4202	**$59.95** (2.39)

Orion® Dew Zapper

Orion's Dew Zapper is a sure-fire cure for dew problems on your 8" or 10" Celestron or Meade Schmidt-Cassegrain telescope. Dew Zapper gently replaces lost heat, bringing the corrector plate temperature slightly above air temperature.

8" Dew Zappers-fit all Meade & Celestron 8" Schmidt-Cassegrains

DC Model #3503, AC Model #3504 **$39.95** (2.39)

10" Dew Zappers- fit all Meade 10" Schmidt-Cassegrains

DC Model #3506, AC Model #3508 **$39.95** (2.39)

Dew Remover Gun

Moisture that interferes with viewing dissipates quickly with this 12V DC, 156 watt warm air gun. Has 4-1/2' cord.

#5601 **$17.95** (2.48)

Starlite Red LED Flashlight

The Starlite is the only adjustable-brightness night-vision red flashlight. Lifetime solid-state LED can't burn out. Extra efficient electronic circuit for long battery life. Uses one 9-volt battery (not included).

#5714 **$24.95** (2.11)

Astronomer's Flashlight

Indispensable and indestructible. Has special night-vision red filter and a diffusion lens for even illumination. An essential addition to your astronomy accessories. Requires 2 D-cell batteries (not included).

#5701 **$9.95** (1.89)

Rechargeable Battery Porta-Pack

12 Amp Hour Porta Pac
Ideal for operating your telescope plus higher power-consuming accessories such as an Orion Dew Zapper. Battery is encased in high-impact polystyrene. Carrying case of Cordura nylon with shoulder strap and handle. Wt. 10 lbs.

#2354 **$99 ea.** (6.23)

Orion® Dual Balance System

Unlike ordinary counter-weights, our system allows instant adjustment in both directions. Easily balances your scope to offset both piggyback loads or rear-cell cameras, 2" diagonals, and other accessories. Rigid, precision machined dovetail bar mounts to telescope in existing accessory holes.

For Meade SC 8"	#5150	**$74.95** (4.65)
For Celestron 8" C-8	#5149	**$79.95** (4.65)
For Meade SC 10"	#5152	**$84.95** (4.65)

Orion® T-Adapter

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 8", 10" SC.

#5116 **$27.95** (1.89)

Orion® UltraGuider

NEW!

Our newest off-axis guider for Celestron and Meade Schmidt-Cassegrain scopes. Easily adjustable prism allows wider choice of guide stars. Heavy no-flex construction. Precision helical focuser for your guiding eyepiece. Adjustable camera focal plane position. Suitable for advanced deep-space astrophotography. Compare our price!

#5139 **$119** (2.79)

Standard Off-Axis Guider
Name brand quality at a low Orion price! Our popular, precision anodized guider with fully coated prism.

#5144 **$59.95** (2.59)

Rack & Pinion Focusers

NEW!

Perfect for telescope makers or upgrading existing telescopes. These top quality focusers are designed specifically for Newtonian reflectors. Chrome plated brass & black enamel finish. Two sizes to fit your needs. Fit any size tubes.

1.25" Focuser
Quality diagonal-cut rack for smooth focusing. Secure slide-fit eyepiece holder. Integral socket for single-stalk diagonal support if desired. Knurled focus knobs.

#13017 **$44.95** (2.39)

2" & 1.25" Focuser
Large clear diameter ideal for larger scopes and wide-field optics. Massive oversized knurled knobs for easy fine focusing. Precision diagonal cut rack. Long travel for both visual and photographic use. Interchangeable 2" and 1.25" holders with set screws.

#13019 **$69.95** (3.31)

Orion® 45-Degree Erect Image Diagonals

NEW!

See the world as it really is with Orion's new 45-degree erect image diagonal. Upside-down, backwards and topsy-turvy images can often confuse even the stoutest and most experienced observer. Turn it right-side-up with your choice of three models to select from.

.965 Diagonal	#8759	**$59.50** (2.59)
1-1/4" Diagonal	#8753	**$59.50** (2.59)
Size-Adapting Hybrid Diagonal	#8755	**$59.50** (2.59)

Star Diagonals

1.25" Star Diagonal
Primarily for astronomical use, lets you view at a right angle. Multi-coated, for 1.25" eyepieces.

#8763 **$39.95** (2.39)

.965" Star Diagonal
Same as 1.25" Star Diagonal, but with standard coated optics. Works with .965" eyepieces and eyepiece holders.

#8761 **$24.95** (1.89)

2" Star Diagonal

Get the widest possible field of view from your Schmidt-Cassegrain Telescope. This star diagonal features a special aluminized and overcoated precision first-surface flat mirror.

#8767 **$89.95** (2.89)

Orion® Tele-Extenders

For high powered photography with your Meade, Celestron 8", 10" Schmidt-Cassegrain

Standard Tele-Extender
Use this Tele-Extender in conjunction with an eyepiece. Attaches to visual back of Meade or Celestron Schmidt-Cassegrain telescopes, and to 35mm camera with T-ring, sold separately.

#5125 **$27.95** (1.89)

Variable Tele-Extender
Uses an adjustable extension tube, allowing magnification to be changed without switching eyepieces. Thumbscrews lock extension tube securely in place. Attaches to 35mm camera with T-ring, sold separately.

#5127 **$39.95** (1.89)

Universal Camera Adapters

Standard Universal Camera Adapters
Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring (sold separately) to match your 35mm camera.

.965" #5268 **$29.95** (1.89)

1.25" #5264 **$34.95** (2.39)

Variable Power Camera Adapter

Unique sliding barrel design allows variable projection distances during eyepiece projection photography, eliminating the need to change eyepieces when magnification changes are required.

#5262 **$44.95** (2.39)

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Vista Binocular Guider

For 20x80mm and under

- Eliminates tripod-hugging when looking up
- Swivels 360° and views from zenith to horizon

GUIDER **$130**
Shipping & handling in USA $5; Canada $10; CA res. add 6¾% sales tax
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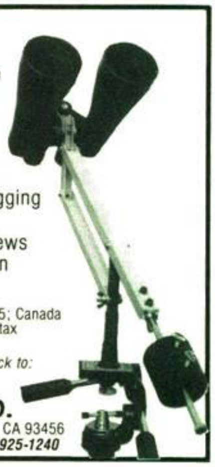

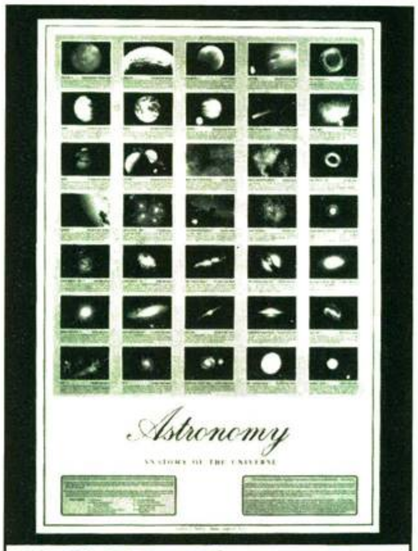

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The Astronomy Poster

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- Descriptions & distance under each photo

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Product Reviews

THREE DEEP-SKY DATABASES

AstroBase Plus, (Zephyr Services, 1900 Murray Avenue, Dept. A, Pittsburgh, PA 15217; (800) 533-6666. For IBM and compatibles. $59.95.

NGC 2000.0 with Optimizer, (Sky Publishing Corporation, P. O. Box 9111, Belmont, MA 02178-9111; (617) 864-7360). For IBM and compatibles. $49.95. (Macintosh version of NGC 2000.0 database but without Optimizer program also available for $24.95.)

The Arizona Database 6.0/AZVUE 2.0, (The Arizona Database Project, Inc., 3135 South 48th Street, Suite 3, Tempe, AZ 85282). For IBM and compatibles. $89.95.

In the last few years, backyard astronomers have been inundated with reference guides for deep-sky observing. Most of these books have included large catalogs of deep-sky targets, some listing columns of data, others providing lengthy descriptions of the visual appearances of objects. One of the books I have found most useful is the *1000+: The Amateur Astronomer's Field Guide to Deep Sky Observing,* which was first published in 1987 by Tom Lorenzin. Its most useful feature for me has been the annotated guide to the more than 1,000 deep-sky objects that Lorenzin observed with an 8-inch Schmidt-Cassegrain telescope. Another new book I now carry with me as an essential observing aid is Chris Luginbuhl and Brian Skiff's *Observing Handbook and Catalogue of Deep-Sky Objects.* It contains detailed descriptions of a more extensive set of deep-sky objects. Both these new books complement the information provided in more venerable works such as *Burnham's Celestial Handbook and the Sky Catalogue 2000.0 Volume 2.*

All these books and catalogs are essentially databases of information about hundreds, if not thousands, of entries. Wouldn't scanning through such databases be much easier if they were in computer-readable format? The answer is yes, and several suppliers have responded to the need by providing computer software that puts deep-sky catalogs onto diskettes. With your home PC you can then search through the database, selecting only those objects that meet certain criteria. These computerized databases make it easy to select objects for a night's viewing, especially for those with large-aperture telescopes who may wish to search among lists of thousands of faint objects. I looked at three such programs, all of them designed to run on an IBM-PC or compatible computer.

The least elaborate of the three programs is AstroBase Plus. It is published by Zephyr Services, who has a wide selection of astronomy software for PCs and Apple II computers. AstroBase Plus allows you to search through a database of 500 objects. You may add as many as 1,500 additional objects to the database. You can also make log entries of personal comments and descriptions of the objects you have observed. This is a nice way to build up a computerized record of your explorations of the night sky. Allowable operations include searches by date, time and location, official designation, constellation, and type of object. You can also specify search ranges of angular diameter, magnitude, and dates observed. For example, you might want to call up only those objects that you previously observed before or after a certain date or during a certain time period, say, at a recent star party. Handy capabilities like these show you the power of a computerized database.

With AstroBase Plus, once you have completed a search you can view the results on the screen or print them on either paper or on 3- by 5-inch filing cards. Zephyr has announced an upgrade, AstroBase Super, which they promise will add many new features to a greatly expanded database. I understand the new price will be $89.95 but I have not yet had the opportunity to evaluate this new version.

While Zephyr's AstroBase Plus contains a much smaller database than the other two products, it's all many observers may need. It also has the advantage of being able to function on computers with only 256K of memory and does not require a hard disk.

A more elaborate program than AstroBase Plus is Sky Publishing Corporation's NGC 2000.0. Available first in book format, the computer disk version of the NGC 2000.0 catalog has been available for about 18 months. It sells for only $19.95 for IBM-format disks. Although it includes two search programs on the diskettes, both are very slow. To improve upon their performance, Dan Gray has written a program called NGC 2000.0 Optimizer. For $49.95 you can buy both the NGC 2000.0 and the Optimizer program

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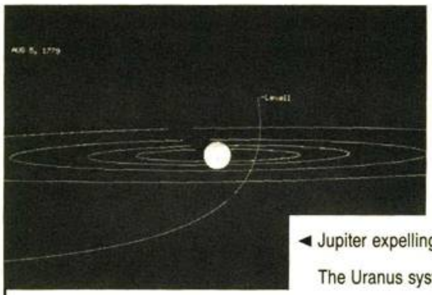

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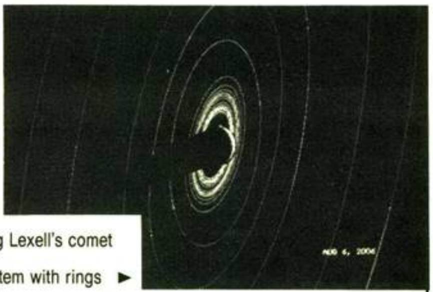

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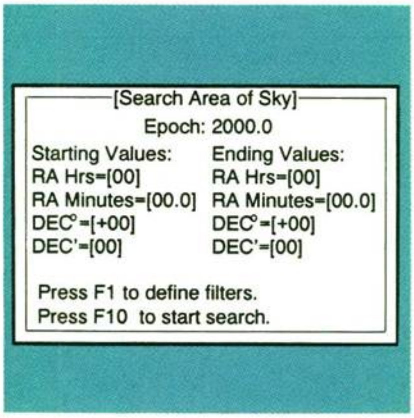
from Sky Publishing. The programs will run off a diskette but a hard disk with at least 1 megabyte of available space is recommended.

NGC 2000.0 Optimizer is very fast. Even on an old 8088-based PC it will perform searches in less than two seconds. On a 16 MHz 80386-based PC, I found that searches were almost instantaneous. In addition, Gray has provided an extensive set of features that make the program a pleasure to use. For example, help is available just by pressing the F1 key and then using the arrow keys to move to the desired topic. You may set up search criteria for such things as the desired catalog (NGC, IC, or both), declination and magnitude limits, and whether to search particular constellations. You can display either selected objects or objects closest to a specified set of coordinates. In addition, there is an excellent set of options for printing your results.

However, while both AstroBase Plus and the NGC 2000.0 programs are excellent, my favorite of the database trio is The Arizona Database. I first encountered this program in 1990 at the Texas Star Party. Software authors Bob Erdmann and George de Lange were handing out free copies of version 5.5 of the program. I was impressed with this earlier version and purchased version 6.0 , the version reviewed.



```
[Search Area of Sky]
              Epoch: 2000.0
Starting Values:           Ending Values:
RA Hrs=[00]                RA Hrs=[00]
RA Minutes=[00.0]          RA Minutes=[00.0]
DEC°=[+00]                 DEC°=[+00]
DEC'=[00]                  DEC'=[00]

Press F1 to define filters.
Press F10 to start search.
```

THE SEARCH MENU for The Arizona Database allows you to search defined areas of the sky for a selection of its 23,000 deep-sky objects.

The Arizona Database has evolved over a period of three years and has grown to include more than 23,000 deep-sky objects compiled from hundreds of sources. Many, perhaps most, of these source catalogs would be inaccessible to the typical observer. The size of the database does come at a price — it takes about 5 megabytes of hard-disk space. However, the speed is fast, with most searches taking no more than a few seconds.

The records in this massive database include twenty or more data fields for each object. An object is identified both by its most common catalog designation and by each of the other designations the authors have been able to verify. In total, there are more than 43,000 object designations included in the database. The program allows you to select an object by either its primary or secondary catalog designations. The object coordinates are for epoch 2000.0 but you can set the epoch for any value between 1700.0 and 2200.0. The authors have also spent hundreds of hours correcting known errors in source databases and in proofreading the contents of their database.

The Arizona Database also contains a feature I have wished for but have never seen before. This program gives you the *Uranometria 2000.0* and *Sky Atlas 2000.0* chart numbers for the area of the sky that includes the object in question, a great convenience. In addition to including the somewhat cryptic descriptions from the NGC and Index Catalogues, this newest version of The Arizona Database also provides the page numbers for Luginbuhl and Skiff's handbook for each object listed there.

Earlier versions of The Arizona Database were provided in "dBASE III" format and users had to employ dBASE to conduct the searches. However, dBASE is not the easiest program to learn, nor would all buyers have dBASE on their computer. To correct this limitation, the authors are now supplying AZVUE, a search program they have created. AZVUE allows you to browse the database and displays all available information about an object in a single, easy-to-read window. AZVUE has very powerful single and multi-object search capabilities — you can define an area of the sky and search for all of the objects within those boundaries, or just a "filtered" set of objects defined by magnitude limits and object type. AZVUE can also search by constellation or by *Uranometria* chart number. You can print out search results as observing lists. Finally, AZVUE contains more than 2,600 lines of on-line help.

In conclusion, each of these three programs performed admirably. While I preferred the The Arizona Database, I can recommend either of the other two programs for those looking for a less comprehensive deep-sky database for their home PC. — Tom Mote

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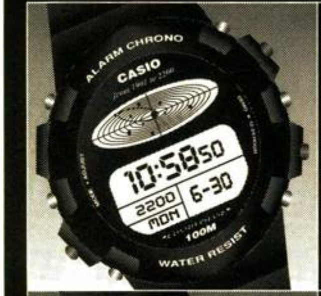

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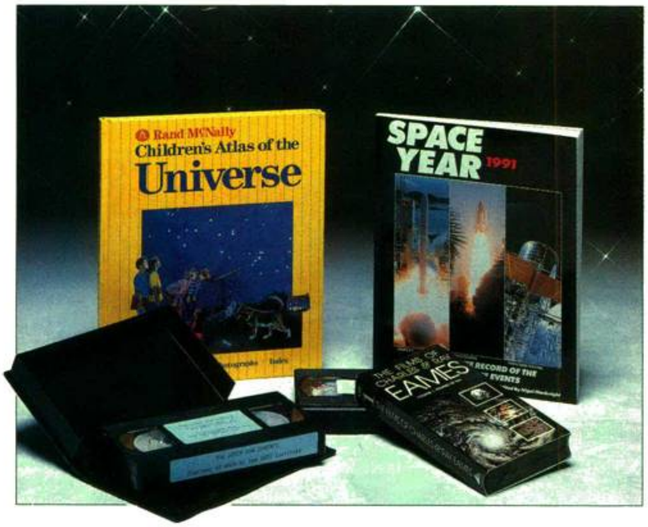

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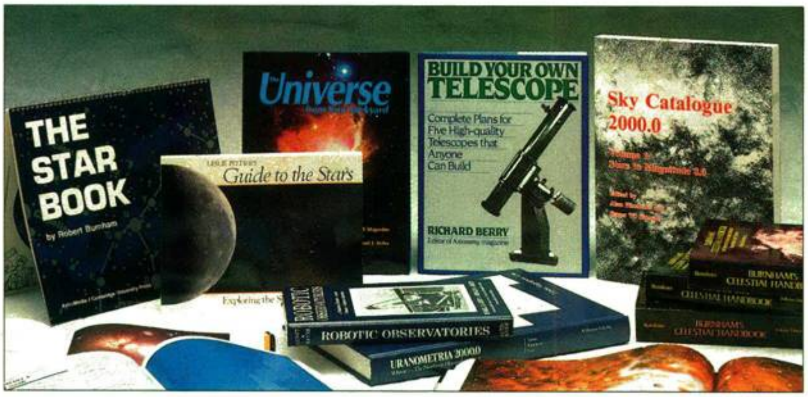

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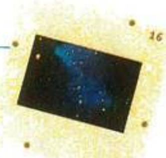

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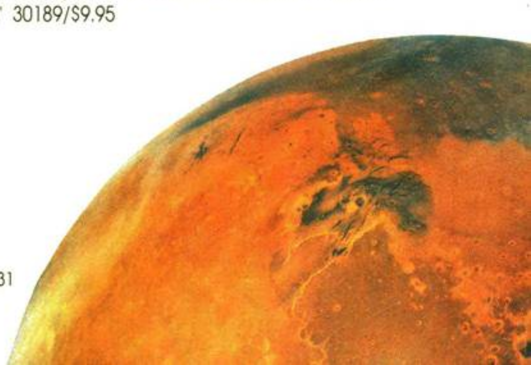

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A GREAT GUIDE TO BINOCULAR ASTRONOMY

Touring the Universe Through Binoculars, by Philip Harrington, (John Wiley & Sons, 1990) ISBN 0-471-51337-7, 294 pages, paperback, $24.95.

At a time when backyard astronomy increasingly involves computers, CCDs, and big light-bucket telescopes, it's refreshing to see a new, well-done guidebook written about binocular observing.

I like exploring the night sky with binoculars. They put you in touch with the universe in a way that large scopes never can. The binocular universe is a more personal universe and one more easily shared, perhaps because the jump from the naked-eye view to the binocular view isn't overwhelmingly great.

In a too-brief introductory chapter, Harrington discusses the advantages of using binoculars. He then takes the reader on a well-guided tour of the Moon in chapter 2. He discusses craters, maria, and other features visible to observers with steadily supported binoculars. His two lunar "maps" are photos of the Moon at First and Last Quarter with labels to mark the features. The descriptions of features give readers the feeling that someone is standing next to them explaining what they are seeing. The chapter concludes with information on occultations and lunar eclipses.

He then goes on a tour of the solar system with a good chapter on observing the planets with binoculars. Here, Harrington does the reader a service by explaining that the observer may be disappointed by some planetary sights. "Mars reveals little," he says. And Jupiter's Great Red Spot "is too small for even the highest power glasses to resolve." This may disappoint, but it's honest.

Harrington then discusses asteroids, comets, and meteors in "The Minor Members of the Solar System." Chapter 5 discusses how to use your binoculars to view the Sun safely by projection. (All through these chapters Harrington reminds you that the best views come when the binocular is securely mounted.)

An examination of the various types of deep-sky objects in "Stellar Happenings" (chapter 6), leads up to the real heart of the book — chapter 7, "A Survey of the Night Sky." This covers each constellation (all 88, including the southern ones) in alphabetical order and gives readers over 1,100 targets for their binoculars. Of these, some 400 get a more detailed examination. Harrington's descriptions are excellent: clear and easy to understand, they give a good indication of what you can actually see.

In addition to the usual double stars, variables, and Messier and NGC objects, Harrington has selected a dozen asterisms to which he gives "Hrr" numbers. These "Harrington catalogue" members are officially unrecognized objects the author feels are worth a look.

The book concludes with several appendices. These cover buying, mounting, maintaining binoculars, and converting local time to universal time. Harrington also provides lists of astronomical societies, binocular manufacturers, and good books for further reading.

I have two points to quibble about. First, good as it is, the book is not for the rank beginner because it assumes the reader already knows something about the basics of astronomy. Second, I was bothered by some of the photos sprinkled throughout the book. Beautiful as they are, they mislead because they don't often show what you're going to see in binoculars. However, neither of my objections detracts from the overall good effect of the book, which is to gently nudge the new observer out into the night to experience the universe.

I enjoyed this book and recommend it to anyone who wants a good guide to the beauty of the night sky. Phillip Harrington has done an excellent job of sharing his universe with the rest of us.
— *Michael Porcellino*

Galaxies & Cosmology

Our Universe: An Armchair Guide, by Michael Rowan-Robinson, (W. H. Freeman, 1990), ISBN 0-7167-2156-2, 180 pages, hardcover, sewn binding, $24.95.

"When did we stop looking at the sky?" asks Michael Rowan-Robinson, recognizing that stay-inside astronomy is all of astronomy for most people. To bring the real astronomy indoors and to illustrate the variety of things in the known universe, Rowan-Robinson has chosen 20 objects as keys to a set of lively and informative essays. These are not mysterious objects, visible only in whopping big telescopes. More than half of them are visible to the naked eye and all (except one) have been known for at least 200 years and can be seen in binoculars or a small telescope.

Colliding Galaxies, by Barry Parker, (Plenum Publishing, 1990), ISBN 0-306-43566-7, 298 pages, hardcover, $23.95.

Subtitled "The Universe in Turmoil," *this book by an astronomer/popular* science writer is about what happens when Big Things collide. Parker focuses his

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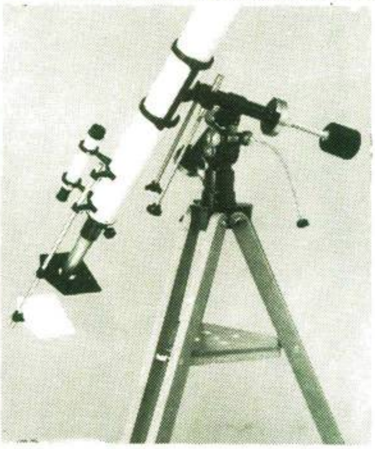

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story around the personalities of astronomers and tells how they began to understand that the space between the stars and the galaxies was neither empty nor peaceful. Along the way, Parker explains radio galaxies, jets, black holes, accretion disks, and the mysterious whatever-it-is that lies at the heart of the Milky Way.

The Planets

The New Solar System, third edition, edited by J. Kelly Beatty and Andrew Chaikin, (Cambridge University Press, 1990), ISBN 0-521-36162-1 (hc), 326 pages, hardcover, $39.95; paperback, $24.95.

First published in 1981, *The New Solar System* (in its two previous editions) has been a compendious, reliable standby of facts and data for every planet buff. This new edition has 23 up-to-date chapters written by expert planetary scientists who examine every possible topic relating to the solar system. The Sun, comets, asteroids, meteorites, and of course planets (from interiors to exospheres) are explored in detail. With *Voyager's* planetary mission now over, and with *Galileo's* most important discoveries still to come, this book comes at a good time to take stock of what we know about the Sun's family.

QUICK PICKS

Interstellar Matter

Molecular Astrophysics, edited by T. W. Hartquist, (Cambridge University Press, 1990), ISBN 0-521-36331-4, 484 pages, hardcover, $79.50.

Molecular Collisions in the Interstellar Medium, by David Flower, (Cambridge University Press, 1990), ISBN 0-521-32032-1, 133 pages, hardcover, $59.50.

Galaxies

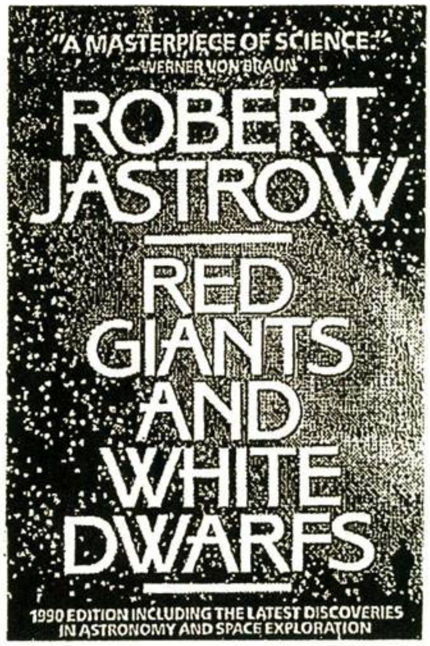
The Milky Way as a Galaxy, by G. Gilmore, I. R. King, P. C. van der Kruit, (University Science Books, 1990), ISBN 0-935702-62-8, 392 pages, hardcover, no price given.

Windows on Galaxies, edited by G. Fabbiano, J. S. Gallagher, and A. Renzini, (Kluwer Academic, 1990), ISBN 0-7923-0663-5, 383 pages, acid-free paper, hardcover, $99.

Instruments

Imaging X-ray Astronomy, edited by Martin Ellis, (Cambridge University Press, 1990), ISBN 0-521-38105-3, 348 pages, hardcover, $49.50.

CCDs in Astronomy, edited by George H. Jacoby, (Astronomical Society of the Pacific, 1990), ISBN 0-937707-25-2, 407 pages, hardcover, $32. ☐



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I.A.P.P.P. Symposium/12th Annual Fairborn Symposium, University of Nevada in Las Vegas, Nevada. Contact: Diane Pyper Smith, Physics Department, University of Nevada, Las Vegas, NV 89154.

March 14-16
4th Annual Chiefland Star Party, Chiefland, Florida. Sponsored by the Tampa Area Astronomical Society. Contact: John Novak, 9890 82nd Street North, Largo, FL 34647. Phone: (813) 392-4669

March 30
Astrophoto IX, Thousand Oaks, California. Sponsored by the Ventura County Astronomical Society. Contact: VCAS/Astrophoto IX, P. O. Box 982, Simi Valley, CA 93062.

April 12-14
3rd International Dark-Sky Association Meeting, Hotel Park, Tucson, Arizona. Contact: IDA, 3545 North Stewart Avenue, Tucson, AZ 85716.

April 13
45th Annual Astronomical League North Central Regional Convention, De Pere, Wisconsin. Sponsored by the Neville Public Museum Astronomical Society. Contact: Ronald Parmentier, 161 Rosemont Drive, Green Bay, WI 54301.

April 19-21
Adult Astronomy Camp, University of Arizona, Tucson, Arizona. Sponsored by The University of Arizona's Alumni Association and Steward Observatory. Contact: Joan L. Morrill, Arizona Alumni Association, 1111 N. (800) 232-8278 (outside Arizona), or (602) 621-5233 .

April 20
Astronomy Day. Contact: Gary Tomlinson, Astronomy Day Coordinator, c/o Chaffee Planetarium, 54 Jefferson SE, Grand Rapids, MI 49503. Phone: (616) 456-3987.

April 20
Astronomy Day and 60th Anniversary Celebration, Madison, Wisconsin. Sponsored by the Madison Astronomical Society. Contact: Bob Manske, 404 Prospect Street, Waunakee, WI 53597, (608) 849-5287; or Dave Weier, 205 Cameo Lane, Madison, WI 53714, (608) 241-1444.

April 23-26
28th Space Congress, Cocoa Beach,

Florida. Sponsored by the Canaveral Council of Technical Societies. Contact: Canaveral Council of Technical Societies, P.O. Box 321333, Cocoa Beach, FL 32932.

May 10-11
AstroFestival '91, Roberson-Kopernik Observatory, Vestal Center, New York. Sponsored by the Kopernik Astronomical Society. Contact: Roberson-Kopernik Observatory, Underwood Road, Vestal Center, NY 13850. Phone: (607) 772-0660.

May 11
Family Astronomy Day, Southold, New York. Sponsored by the Custer Institute. Contact: Custer Institute, Main Bayview Road, P.O. Box 1204, Southold, NY 11971. Phone: (516) 765-2626.

May 17-19
General Assembly of the Royal Astronomical Society of Canada, Vancouver, British Columbia. Contact: David Dodge, Vancouver Centre of the Royal Astronomical Society of Canada, Gordon Southam Observatory, 1100 Chestnut Street, Vancouver, BC, Canada V6J 3J9.

May 22-27
10th Annual International Space Development Conference, San Antonio, Texas. Sponsored by the National Space Society, Kelly Air Force Base, and the San Antonio Space Society. Contact: Carol Luckhardt Redfield. Phone: (512) 522-3823.

July 8-12
Research Amateur Astronomy Symposium, La Paz, Baja California Sur, Mexico. Contact: Corporation for Research Amateur Astronomy, P.O. Box 16542, San Francisco, CA 94116.

August 7-9
45th Annual Astronomical League National Convention, University of Massachusetts, Amherst, Massachusetts. Hosted by the Amateur Telescope Makers of Boston. Contact: John Reed, 1437 Massachusetts Avenue, Lexington, MA 02173. ☐

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Readings and Resources

Galileo at Earth (page 30)

"Bound for Jupiter" by Joel Harris, ASTRONOMY, January 1990. Outlines the mission now underway.

Tracking the Great White (page 36)

The Planet Saturn by Arthur Alexander, (Faber and Faber, 1962). The standard work on telescopic observations of Saturn up to 1960. Now out of print, but a must for any die-hard Saturn watcher.

Saturn by Garry Hunt and Patrick Moore, (Rand McNally and Company, 1982). A popular-level look at the *Voyager* discoveries at Saturn.

Southern Radio Sky (page 39)

"The Magnetic Milky Way" by Gerrit Verschuur, ASTRONOMY, June 1990. Explores the omnipresent role of magnetic fields in organizing matter in the Milky Way Galaxy.

Gathering of Galaxies (page 44)

The Realm of the Nebulae by Edwin Hubble, (Yale University Press, 1982). A reprint of Hubble's classic 1936 work, in which he summarized astronomers' knowledge of the galaxies just over a decade after he proved that they lie far beyond the Milky Way.

Out of the Darkness by Clyde W. Tombaugh and Patrick Moore, (Stackpole Books, 1980). Tombaugh's own account of the discovery of Pluto and the photographic search techniques that led him there.

The Virgo Cluster (page 70)

Atlas of Deep-Sky Splendors by Hans Vehrenberg, 4th ed., (Cambridge University Press, Sky Publishing Corp., and Treugesell-Verlag, 1984). A pictorial atlas of regions of deep-sky objects, including all Virgo galaxies.

Observing Handbook and Catalogue of Deep Sky Objects by Christian Luginbuhl and Brian A. Skiff, (Cambridge University Press, 1990). An excellent observational summary of the Virgo galaxies.

Joy of Moongazing (page 84)

The Moon, by Edmund Neison, (Longmans, 1876), and *The Moon,* by H. Percy Wilkins and Patrick Moore, (Faber and Faber, 1961). Both are classic encyclopedias of the map-and-description genre and worth hunting for in libraries (despite the fact that their discussions of lunar geologic processes are out of touch with our present understanding).

A New Photographic Atlas of the Moon, by Zdenek Kopal, (Taplinger, 1971). A relatively recent and thoroughly illustrated guidebook.

CREDITS

p. 4: NASA; *p. 14:* Dan Gordon, 8-inch SCT, 20 minutes on Ilford XP-1 at f/5.7; *p. 22:* Annie Allison and Alfred McEwen, USGS, Flagstaff, Arizona; *p. 24:* European Southern Observatory; *p. 26:* John Ginder, Toronto Centre, R.A.S.C; *pp. 30-34:* NASA/JPL; *p. 36:* NASA/STSI; *p. 37:* illustration by Tom Hunt; *p. 38:* Scott Murrell, 24-inch telescope at Tortugas Mountain, Las Cruces, New Mexico, 4-second exposures at f/40, CCD image deconvolution by Pedro Sada, images courtesy Reta Beebe, New Mexico State University; *pp. 39-43:* antenna photos, courtesy George Nicholson, Hartebeesthoek Radio Astronomy Observatory, sky images courtesy Justin Jonas, Rhodes University; *pp. 44-45:* illustration by Shelby Keefe; *pp. 47-51:* copyright 1979 by the Anglo-Australian Telescope Board; *p. 48:* illustration by Tom Hunt; *p. 56:* sketch by E. Leopold Trouvelot, coutesy Fairfield County Astronomical Society; *p. 65, top:* Patrick Martinez, 500mm lens at f/3.5, Fujicolor 1600 film, 1/500-second exposure; *p. bottom left:* Patrick Martinez; *p. bottom right:* Patrick Martinez, 300mm lens at f/2.8, Fujicolor 1600 film, 1/250-second exposure; *p. 66, top right:* Michael Stecker, Takahashi 8-inch f/4 telescope, hypered Tech Pan film, November 17, 1990; *p. bottom right:* Dan Schecter, 14-inch f/11 SCT, Fujichrome 100 film; *p. left:* Jeffrey L. Jones, 8-inch f/10 SCT, hypered Tech Pan, 15-minute exposure, October 22, 1990; *p. 67:* Bill and Sally Fletcher, 16-inch f/5 reflector, hypersensitized Konica 1600 film; *pp. 68-69:* Tony Hallas and Daphne Mount, 6-inch f/7.5 EDF refractor, hypered Fujichrome Super HG 400 film, 60-minute exposure; *p. 68, left:* Charles Crauford, 50mm f/2.8 lens, Agfachrome 1000 film, 3-minute exposure; *p. right:* Charles Crauford, 10-inch reflector, Konica 3200 film, 15-minute exposure; *p. 69, top:* Martin Guth, 28mm lens at f/2.8, Kodak VRG 1600 film, 20-second exposure; *p. bottom:* James R. Brunkella, 5.5-inch Schmidt-Newtonian telescope, T-Max 100 film, 1/30-second exposure, August 21, 1990, 7:55 PDT; *pp. 70-71:* Anglo-Australian Telescope Board; *p. 72:* Patti L. Keipe; *p. 73, top:* Jack Newton, 20-inch f/5 reflector, Fujichrome 400 film, cold camera, 20-minute exposure; *center:* Martin C. Germano, 8-inch f/10 SCT, 103a-F film, 30-minute exposure; *bottom:* Martin C. Germano, 8-inch f/10 SCT, 103a-F film, 75-minute exposure; *p. 74:* Kim Zussman, modified 11-inch f/10 SCT, hypered Tech Pan film, 140-minute exposure; *p. 75, left:* Jack Newton, 20-inch f/5 reflector, 20-minute exposure; *right:* Jack Newton, 16-inch f/5 reflector, 16-minute exposure; *p. 76, top:* Rick Dilsizian, 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 10-minute exposure; *center:* Martin C. Germano, 8-inch f/10 SCT, 103a-F film, 75-minute exposure; *bottom:* Martin C. Germano, 8-inch f/10 SCT, 103a-F film, 70-minute exposure; *pp. 78-83:* all photos by Chris Becker and Darla Gawelski; *pp. 84-89:* Gérard Therin, 8-inch SCT, Technical Pan film, 1.3-second exposures at f/60 or f/70 (eyepiece projection).

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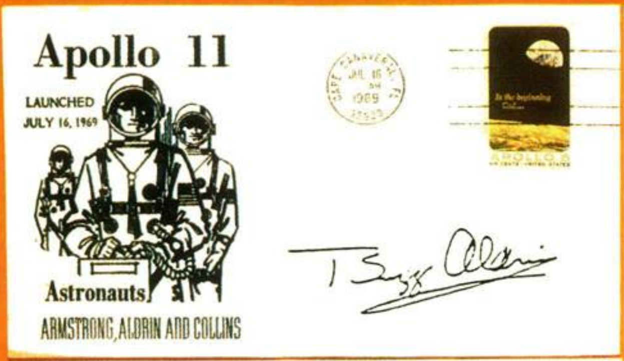
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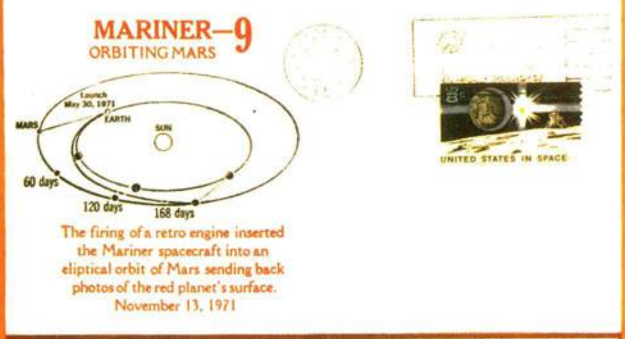
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